CHAPTER 5 : RESULTS AND DISCUSSION

5.1 SIMULATION OF SIGNAL CONDITIONING CIRCUITS

The critical problem of product design and testing is simplified by use of PSpice simulations. This allows user to design, test, and perform various analysis to optimize the accuracy, circuit performance and its reliability before the actual product is made [1]. This chapter addresses performance of signal conditioning circuits used for various sensors. Low cost circuit design, with an accurate, linear and faster testing technique is addressed.

The circuit simulation for signal conditioning is performed by experimenting various resistance, capacitance or input voltage values in the test circuit. In reality the circuit has to simulate over the specified operation ranges. The low cost, fast simulation techniques for the linearity and an accuracy of the circuit performance and reliability is reported by using the Pspice test tools. The results are explored with browsing output data facility and run probe analysis. Following section gives the performance of signal conditioning circuit for J type thermocouple as an example.

5.1.1 CIRCUIT SIMULATION FOR J-TYPE THERMOCOUPLE

The J-type thermocouple is used frequently in industry because it is economical and has high output in millivolts over its temperature range. Due to relatively low voltage output associated with most thermocouples, amplification circuit is used to increase sensitivity. The resulting output of this circuit is used to drive or activate a readout device [2].

PSpice simulations and testing process is as follows.

- Drawing the circuit
- Selecting the type of analysis
- Simulation of the circuit
- Displaying the results of the simulation
Initially the circuit is designed and drawn, as shown in Fig 5.1, using PSpice evaluation version Microsim Eval 7.1. To test and analyze the circuit performance for J type of thermocouple first initial conditions such as zero and span are set by varying the values of R8 and R25.

![Fig 5.1 Signal Conditioning Circuit for J Type Thermocouple](image)

To test the circuit, initially the input is connected to the ground and R25 was adjusted to get a voltage in mV, which corresponds to room temperature. Then input 6 mV, which corresponds to 100°C, was applied later and R6 was adjusted for span adjustment i.e. to get 1V at the output. The DC input voltage was then swept in the range from 0mV to 6mV in step of 0.1mV using PARAM. The performance dependence characteristic on output is shown in Fig 5.2. It shows that as input voltage increases the output voltage also increases and this change is linear. This circuit converts the change in thermocouple voltage in mV into the corresponding change in output voltage from 0 to 1V.
The designed circuit was then actually built using discrete components and a simulated input voltage from 0 to 6 mV was applied at input of the circuit using potential divider. Fig 5.3 shows variation of output voltage with respect to changes in input voltage. It also shows that the increase in input voltage also increases the output voltage linearly.

Fig 5.2 PSpice Simulated response for J type Thermocouple SCC

Fig 5.3 Response of Signal conditioning card for Thermocouple
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The PSpice simulations of sensor signal conditioning circuits was also carried out successfully for all remaining sensors. From fig 5.2 and 5.3 we can conclude that as the input voltage changes from 0-6 mV the output changes from 0-1V for both the circuits.

While testing the signal conditioning circuits for other sensors initially only one circuit was independently tested for only one type and range of measurement by applying the simulated inputs. The zero and span adjustments were carried out so as to produce the fixed range of 0-1V output. The gain of PGA was adjusted manually to provide a fixed range of output 0-5V. A 100 Ohms RTD PT 100 will exhibit 100 Ohms of resistance when temperature is 0°C or 32°F. As its temperature increases likewise its resistance increases and it is 138.5 Ohms at 100°C. Fig 5.4 shows such variation of 0-5V with respect to change in resistance from 100 to 138.5 Ohms [3].

![Response of signal conditioning card for Pt 100](image)

The change in output 0-5V is applied to V to I converter to provide a fixed range of current 4-20 mA. In case of V to I converter as the voltage increases from 0-5 V, the output current increases from 4-20 mA, as shown in fig 5.5.
The same output was also applied to ADC whose digital output changes from 000H to FFFH. In case of ADC as the input analog voltage increases from 0-5V, the digital output increases from 000H to FFFH. For the same signal conditioning circuit the simulated inputs were applied for all remaining types and ranges and every time the gain of PGA was adjusted manually to provide same 0-5V range of output. This procedure was repeated for all eight signal conditioning circuits for all eight types of sensors.

5.3 SPECIFICATIONS OF USI

INPUT SPECIFICATIONS

- THERMOCOUPLES: (B,E,J,K,T,R,S)
- THERMISTORS: (80K,47K,10K,1K)
- RTDs:(PT 50, PT 100, PT 500, PT 1000 for $\alpha = 0.00385$)
- LDR :(20 K)
- LVDT: (2.5 mV/V to 1280mV/V, 0-5mm)
- STRAIN GAUGES :(Typically 350Ω)
• F.O. DISPLACEMENT SENSOR : (0-3mm)
• CAPACITIVE SENSOR : (0-1000 pf)

[TEMPERATURE RANGE OF MEASUREMENT (FOR TEMPERATURE SENSORS) : FROM 0°C to 1800°C]

OUTPUT SPECIFICATIONS

• ANALOG VOLTAGE : 0-5V (750 mA)
• ANALOG CURRENT : 4-20 mA for RL = 250Ω
• PARALLEL PORT : 12-Bit
• RS 232C SERIAL PORT: Baud Rate = 2400

REFERENCES