Use of Computers in Data Acquisition

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Abstract:

Computer Engineering, and Computer Engineering Technology graduates need a clear understanding of analog transducers and the way to connect them to computers via digital interface circuits. In industry, transducers are used to measure temperature, pressure, strain, flow, position, velocity, and other analog conditions. In most two-year, and four-year electronic programs, students generally study transducers with their applications in one analog course, instrumentation amplifiers in a second analog course, and microprocessor interfacing in a separate digital course. The integration of these three topics in which students design, simulate, build and test a data acquisition system will help them to understand a practical industrial application. In this paper we will use a PC Interface card to connect the interfacing circuit which is on a breadboard to the computer. The interfacing circuit will be connected to an analog circuit that measures temperature. All engineering and engineering technology school laboratories are equipped with microcomputers. The advantage of using a PC interface card is that with a moderate cost for interfacing cards, the computers can be used for the programming of the digital circuits which are connected to the analog data acquisition circuit. As an example we will discuss the design, simulation, construction, and programming of a circuit used to display the temperature, as well as indicate high and low temperature alarm conditions. Electronic Workbench for Windows 95 simulation software will be used to simulate the operation of the circuit prior to its actual construction. Next the electronic circuit will be constructed. Finally, the students will write a computer program to control the system, and display the temperature information. The students are grouped into several project teams. This approach is similar to experience they will encounter in industry. Therefore, this project will enforce the team work concept as well as integrating knowledge learned across several electronic classes.
Introduction:

This paper describes a project assigned to students during the last quarter of an Linear Op-Amp electronic class. Figure 1 shows the computer interface system block diagram. A 74LS245 Octal Transceiver chip was used to connect the analog Op-Amp, and the Fiber Optic circuits to the PC-Interface card that resides in an IBM compatible personal computer.

![Schematic Block Diagram of the System](image)

Figure 1 Schematic Block Diagram of the System

The system described in this paper measures temperature, in real time, and displays it on the computer screen. If the temperature is less than, or greater than programmable upper and lower limits, an alarm in the form of “Flashing” text and a “Computer Beep” sounds. Also, for these extreme temperature points, a signal was transmitted through an Optical Fiber Link to a red-color Light Emitting Diode (LED).

System Hardware:

The PC-Interface card can be purchased through the Electronic Industries Association (EIA) [1]. Figure 2 illustrates the pinout diagram of the PC-Interface card. This card can be placed in a 32-pin Industry Standard Association (ISA) port of an IBM compatible personal computer.
The Analog to Digital (0804 ADC) chip converts the analog voltage from the Op-Amp Transducer circuit to digital data. The 74LS245 Octal Transceiver (buffer) chip is used to connect the Analog to Digital Converter (ADC) to the PC Interface Card. Figures 3, 4, and 5 display the schematic diagram of the 0804 ADC, 74LS245, and 74LS373 chips [2].

Figure 2 Pinout Diagram for the PC Interface Card

Figure 3 The 0804 Analog to Digital Converter (ADC)
Figure 4 The 74LS245 Octal Buffer / Driver

Figure 5 The 74LS373 Octal Latch
Figure 6 displays the Op-Amp bridge circuit which is used to convert temperature into a voltage which is then applied to the ADC Circuit as shown.

For this project a thermistor with a reference resistance of 3.3K ohms at 25 degrees Celsius was used. The thermistor input/output characteristic was measured over the temperature range of interest. Table 1 contains the measured data. A graph of the measured temperature in degrees Fahrenheit versus Op-Amp output voltage is shown on figure 7.

<table>
<thead>
<tr>
<th>Op-Amp Output, V</th>
<th>ADC Output</th>
<th>Temperature, F</th>
<th>Temperature, C</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.614</td>
<td>133</td>
<td>35</td>
<td>1.67</td>
</tr>
<tr>
<td>3.331</td>
<td>169</td>
<td>50</td>
<td>10.00</td>
</tr>
<tr>
<td>3.913</td>
<td>199</td>
<td>71</td>
<td>21.67</td>
</tr>
<tr>
<td>4.539</td>
<td>231</td>
<td>110</td>
<td>43.33</td>
</tr>
<tr>
<td>4.662</td>
<td>238</td>
<td>125</td>
<td>51.67</td>
</tr>
<tr>
<td>4.782</td>
<td>244</td>
<td>150</td>
<td>65.56</td>
</tr>
<tr>
<td>4.862</td>
<td>248</td>
<td>175</td>
<td>79.44</td>
</tr>
<tr>
<td>4.916</td>
<td>251</td>
<td>209</td>
<td>98.33</td>
</tr>
</tbody>
</table>

Table 1 Op-Amp Output Voltage, ADC Output, and Temperature
Figure 8 shows the Fiber Optic Link. We have used the Motorola model series MFOE71 Noninverting transmitter, and Motorola model series SN74LS132 receiver [3]. The optical transmitter and the optical receiver were separated by a one meter long fiber optic cable.
Address Decoder Circuit:

On most personal computers the address range 300-to-3FF hex is available for external use. Figure 9 shows the address map of a decoder circuit that will generate the chip-enable signals for this address range.

<table>
<thead>
<tr>
<th>A15 A14 A13 A12 A11 A10 A9 A8 A7 A6 A5 A4 A3 A2 A1 A0</th>
<th>HEX Address Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 0 0 0 0 0 1 1 0 0 0 X X</td>
<td>0300h TO 03FFh</td>
</tr>
</tbody>
</table>

**Figure 9** Address decoding map

The decoder circuit displayed in Figure 10 was built using Transistor-Transistor Logic (TTL) gates. The output of the decoder circuit was connected to the Bus Enable (BEN) pin of the PC interfacing card, and the Enable pin on the 74LS245 Octal Buffer chip.

![Address Decoder Circuit Diagram](image)

**Figure 10** The Address Decoder Circuit

System Software:

The Flowchart of the Quick Basic computer program is displayed on Figure 11. The input data from Analog to Digital Converter (ADC) chip is read. Next, one of the equations for the Piecewise Linear lines of the thermistor curve was used to calculate the temperature. Then, two Conditional Program Statements are used to determine if an alarm condition has occurred. Finally, the temperature value is displayed on the computer screen. Appendix A contains the Basic Program for this project.
Conclusion:

This paper has described how a micro computer can provide a low cost method of interfacing real time, analog transducer data to a micro computer using analog-digital circuits. Using this approach, students were able, in a laboratory setting, to gain practical experience in designing, simulating, building, and programming a practical real world data acquisition system.

Appendix A:

5   CLS
10   PRINT "Press Esc to exit..."
20   PRINT "INPUT HIGH TEMPERATURE LIMIT"
25   INPUT H
30   PRINT "INPUT LOW TEMPERATURE LIMIT"
35   INPUT L  
40   CLS  
45   DO  
REM-----------------------------[INPUT STEP FROM ADC]-----------------------------
50   d = INP(768)  

REM-----------------------------[ASSIGN STEP VOLTAGE]-----------------------------
55   v2 = d * .0196078  

REM-----------------------------[SEND STEP DATA TO TEMP FORMULA]-----------------------------
60   IF d > 251 THEN COLOR 4, 0: GOTO 105: ELSE COLOR 7, 0  
65   IF d >= 248 THEN GOTO 130  
70   IF d >= 244 THEN GOTO 150  
75   IF d >= 238 THEN GOTO 170  
80   IF d >= 231 THEN GOTO 190  
85   IF d >= 199 THEN GOTO 210  
90   IF d >= 168 THEN GOTO 230  
95   IF d > 133 THEN GOTO 250  
100  IF d <= 133 THEN COLOR 3, 0: GOTO 270: ELSE COLOR 7, 0  

REM-----------------------------[OVER RANGE]--------------------------------
105   PRINT " - TEMPERATURE IS OVER 212 DEGREES F - "  
110   FOR i = 1 TO 10000  
115   NEXT i  
120   CLS  
125   GOTO 355  

REM-----------------------------[1ST TEMP RANGE]-----------------------------
130   T = 209  
135   V = 4.922  
140   S = .0016  
145   GOTO 295  

REM-----------------------------[2ND TEMP RANGE]-----------------------------
150   T = 175  
155   V = 4.86  
160   S = .0032  
165   GOTO 295  

REM-----------------------------[3RD TEMP RANGE]-----------------------------
170   T = 150  
175   V = 4.784  
180   S = .0048  
185   GOTO 295
REM-----------------------------[4TH TEMP RANGE]-----------------------------
190 T = 125
195 V = 4.667
200 S = .0082
205 GOTO 295

REM-----------------------------[5TH TEMP RANGE]-----------------------------
210 T = 110
215 V = 4.539
220 S = .016
225 GOTO 295

REM-----------------------------[6TH TEMP RANGE]-----------------------------
230 T = 71
235 V = 3.913
240 S = .028
245 GOTO 295

REM-----------------------------[7TH TEMP RANGE]-----------------------------
250 T = 50
255 V = 3.331
260 S = .048
265 GOTO 295

REM-----------------------------[UNDER RANGE]-----------------------------
270 PRINT " - TEMPERATURE IS UNDER 35 DEGREES F - ">
275 FOR i = 1 TO 10000
280 NEXT i
285 CLS
290 GOTO 355

REM-----------------------------[H/L ALARM]-----------------------------
295 t2 = (T - ((V - v2) / S))
300 CLS
305 PRINT "Hit Esc key to stop"
310 PRINT
315 PRINT "the voltage is "; : PRINT USING "###.##"; v2
320 PRINT "TEMPERATURE F = "; : PRINT USING "###.#"; t2
325 T3 = 5 / 9 * (t2 - 32)
330 PRINT "TEMPERATURE C = "; : PRINT USING "###.#"; T3
335 FOR i = 1 TO 10000
340 NEXT I
342 REM If T <= 0 Degree Celsius, then Sound the Alarm, and Signal to Fiber Optic Link.
345 IF t2 <= L THEN COLOR 0, 3: PRINT : PRINT " - LOW ALARM REACHED - ": PRINT : BEEP:
OUT 769, 128
348 REM If T = > 100 Degree Celsius, then Sound the Alarm, and Signal to Fiber Optic Link.
350 IF t2 >= H THEN COLOR 0, 4: PRINT : PRINT " - HIGH ALARM REACHED - ": PRINT : BEEP:
OUT 769, 128
355 FOR i = 1 TO 10000
360 NEXT i
365 LOOP UNTIL INKEY$ = CHR$(27)

REM-----------------------------[END]----------------------------------------

References:

1. Electronic Industries Association, Consumer Electronic Group, Washington, D.C.
3. Motorola Semiconductor, P.O.Box 20912, Phoenix, Arizona 85036.

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