Analyze Accuracy of Analog to Digital Converter in C

Objective: Example the operation and accuracy of the MC9S12XEP100's ADC. For this lab you will design and write a C language program that reads the potentiometer on Analog to digital converter (ATD) channel 2 and displays the converted digital value as binary output on the LEDs. You will analyze the ADC's linear input/output relationship performance and accuracy.
This is Part II of a two part lab. For Pre-Lab and Part I you will worked individually last week and For this week Part II, you will work in teams.

Part II work in teams: (2nd Week)
Analyze the ADC's linear input/output relationship performance and accuracy. **ADC in C: Comparing Voltage Readings with Quantized Bit (LEDs) Readings**
Once your Part I **ATD converter program** is complete and operates as instructed:
Have the Instructor or TA verify your program operates as instructed.

- Then with your program running you will use a DVM to measure the voltage at TP POT (testing point of Potentiometer) found on the training board. See Picture 1 on last page of these instructions.
- You will vary the potentiometer and record both the DVM readings and the corresponding binary output of the ATD represented on the LEDs.
- You will calculate theoretical input/output relationship, compare theoretical values with measured values and record the quantized value per bit (step value).

  Note: we are using 8-bit mode and V_{ref} = 5 volts.

! Before you begin to take readings: Make sure to read all the instructions and plan how you will arrange and record your data in a table.

To start the readings and record your data:
While your program is running you will:
1. Get the Minimum (min) reading: Turn the potentiometer completely CCW,
   a. Place DVM probes as illustrated in Picture 1.
   b. Ensure the negative probe is on the lead of the capacitor closest to the LEDs.
      i. You should get a DVM reading of ~0 volts.
      ii. All LEDs should be off
2. Get the Maximum (max) reading: Turn the potentiometer completely CW,
   a. Obtain another DVM reading.
      i. You should get a DVM reading of ~2.5 volts.
         ✓ Why not 5 volts?
           Answer: Potentiometer (V_{ref} =5V) on training board uses a voltage divider circuit so output voltage should not exceed ~2.5 volts.
           See lecture slides!
      ii. Observe the binary pattern of the LEDs.
         ✓ You should have more than Two LEDs light. If not, Do not assume something is wrong with the LEDs! Have an instructor examine your code and set-up.

   If you get anything other than these readings, you are not set up properly.
   Please call an Instructor or TA to examine your code and readings.

3. Once you have obtained the limit readings (min and max), you are ready to obtain ***at least seven*** **additional** readings at various potentiometer settings. More readings… results in more data to compare….This is a good thing. Use a table, as described below, to document your readings.
    a. You should do your readings staring either at min (0 reading) and increase consecutively up to max or start at max and decrease consecutively down to min (0 reading). Plan this process and ensure your test points are evenly spaced from min to max and you display them in a logical way in a table.
4. Construct a well-organized table that looks like and contains: See Lecture 10ab Slides for example Table
    a. the DVM V_{in} readings,
    b. LED digital output binary readings,
    c. The equivalent D digital value (decimal value) from the binary reading.
    d. For each change in analog V_{in} (DVM reading): calculate its equivalent D (digital output) value and record in the table next to the full equation. (Equation must show values used for the calculation). This is the theoretical value.
    e. For each change in analog V_{in} (DVM reading): Compute the difference (percentage of Error) of the measured digital output reading verses theoretical ATD Digital output and record in the table. See Lecture slides for example
5. Graphs:
    a. Use your recorded data to produce two Graphs that compare both your measured readings and calculated values with the theoretical calculated values.
        - ✓ Graph of your collected data showing your input/output readings: Analog V_{in} Values vs. Digital (LEDs binary) value. This will show the output characteristic performance of the 8-bit Analog to Digital SAR.
        - ✓ Graph that shows your Analog V_{in} readings vs. Calculated Theoretical Digital (binary) value. This will show the theoretical output characteristic performance of the 8-bit Analog to Digital SAR.
6. In your Table and clearly noted in your report:
    a. Be sure to note values such as step size, both in measured and theory,
    b. Include the best "in theory" the ATD converter can do with 8-bit resolution compared to the measured best performance.
    c. Make additional observations using the I/O data sheet provided in Canvas.
    d. Ask yourself, what intelligent conclusions can you draw from the observed readings and the computed values recorded in the table?
    e. Then write your report.
7. Include in your formal report:
    a. Your data table well organized and clearly labeled
    b. Graph of your collected data showing your input/output readings: Analog V_{in} Values vs. Digital (LEDs binary) value. This will show the output characteristic performance of the 8-bit Analog to Digital SAR.
    c. Graph that shows your Analog V_{in} readings vs. Calculated Theoretical Digital (binary) value. You may use the calculated
    d. Your report must also include all calculations showing the formulas used, and an example for how the equations are used to obtained values. (do not turn in an excel sheet). Embed your excel tables and graphs in your word document.
8. At the completion of this lab: each student must complete a team peer review posted in Canvas Modules: Week 10.

Picture 1
Ensure negative and positive leads are placed as exampled below. Do not use other testing points.

Figure 1:
Example table with one data point reading recorded.

V_{in}: DVM Pot Voltage reading	AtoD Converter output D: Binary Number (on LEDs)		Theoretical Equation	D_{10}	D_2
0.813 V	00101011	(43_{10})	D = ((2^8)-1) * (0.813/5)	(41.463_{10})	00101001

Show all 8 bits

Show all 8 bits

Percent Error:
Where: $\frac{|Theoretical - Measured|}{Theoretical} * 100\%$ using the example data: $\frac{|41.463 - 43|}{41.463} * 100\% = 3.706\%$

Submission Code and Report requirements:
Submit a formal report. You do not need a cover page. Your report must include clear steps of your process and explain your processes, all items clearly marked and well organized. Including an excel table(s) neatly organized and embedded in your report that includes all your data readings and data calculations as required. Graphs as required. Step size and calculation(s) as required. You must show your calculation equations. Include your completed design worksheet with tables. In your conclusions and Discussions: include your observations/comparisons between your voltage readings and the corresponding digital (LEDs) readings as required, step size and Make intelligent, significant conclusions and observations accordingly.

Submit your project code: Submit a zipped folder of your project Code and your main.c file. Your code should be thoroughly commented, well documented, including commented header and your own unique code comments as to what your program is doing. Do not just state something like reading channel 2…return value…etc. Be specific as to what the code is doing in relationship with the hardware for initialization, input and output, show me you understand the code. Follow all good coding practices introduced and enforced in this class.

Submit your zipped project code and formal report. Only one submission per team.