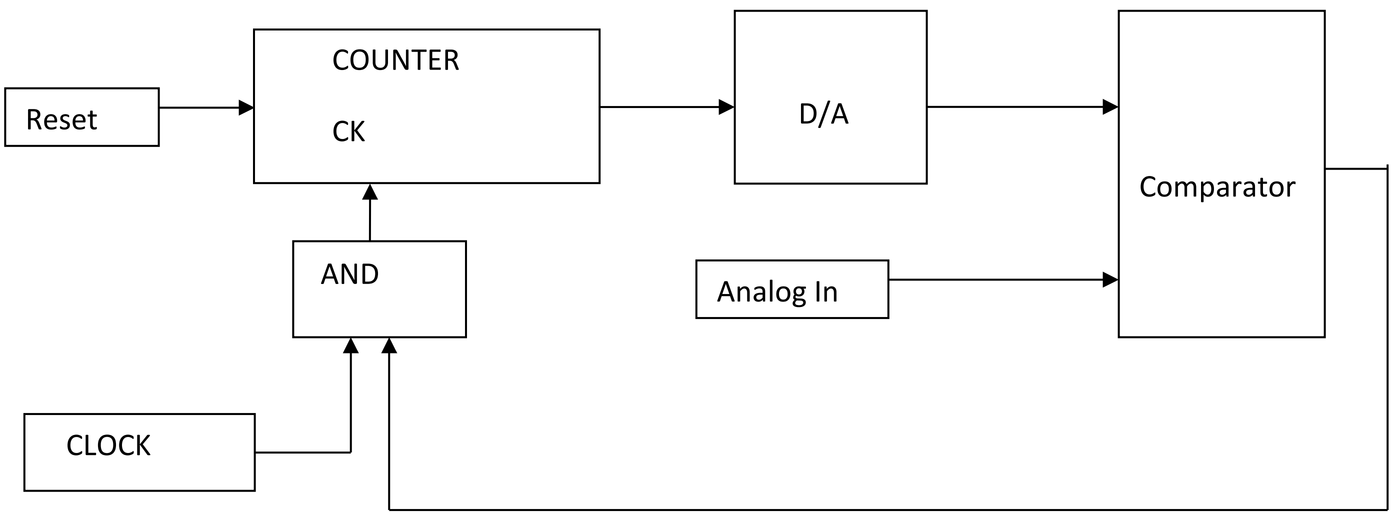
CENG 3331: Lab for Telecom & networks – Lab 4 Quantization, A/D, and D/A Operations

Goals: To understand the concept of quantization as applied to the conversion of analog voltages into digital words and digital words into analog voltages.

1. Introduction

In this Lab, you will learn the counter-comparator A/D conversion process. Study the diagram below and compare it to what you find.

Read through the entire lab and scan any supplied files before starting work. Note, that before running a simulation, you should always have a general understanding of how your circuit works.



2. TASK 1: 4-bit counter

Using Multisim follow the following steps to build an 8-bit synchronous counter.

1. Add Vcc and Digital Ground to your workspace as needed (for the counter).
2. Locate a 74191 4-bit counter and add it to your workspace.
3. Attach pins 1,9,10, and 15 (A, B, C, and D) to the ground.
4. Attach ~ LOAD (pin 11) to 5 volts.
5. Attach ~U/D to the ground.
6. Attach a switch (SPDT for example) to the clock input (pin 14).
7. Attach probes to pin 3,2,6,7 and label each with the proper names (QA, etc.).
8. Save your work. (If possible, put it on a USB memory stick.)

Question:

1. Turn on the simulation and troubleshoot your circuit until you get the 4-bit counter working. Use the switch to single-step the counter. Include your schematic and results in the lab book.

3. TASK 2: 8-bit counter

1. Now expand your counter with a second 74191 4-bit counter.
2. Attach A, B, C, and D of the second chip to the ground.
3. Attach ~U/D of the second chip to the ground.
4. Attach ~LOAD (pin 11) of the 2nd chip to 5 volts
5. Connect the carry out (~RCO, pin 13) of the first counter to the clock of the 2nd counter (pin 14.).
6. Attach probes to the QA, QB, QC, and QD outputs of the second 4-bit counter and label them. Use QA1, QB1…. or QE, QF, QG, QH, or whatever works for you to emphasize that the extension will be an 8-bit counter.
7. Save your work.

Question:

1. Turn on the simulation and troubleshoot your circuit until you get the 8-bit counter working. Include your schematic and results in the lab book.

4. Task 3: Investigate a generic VDAC (Digital to Analog Converter--Voltage Output)

1. Locate the VDAC and add it to your workspace (look under all groups, all families, then search for VDAC).
2. Attach a 1-volt DC power source (VDAC reference voltage) to the + of the VDAC, then attach ground to the –input of reference.
3. Attach a voltmeter to the output of the DAC-V (right-hand side pin.)
4. Attach switches (in Multisim 11.0 the inputs are 0 unless attached to 5volts) to inputs 0, 1, 2, 3, 4, 5, 6, 7, to act as TTL inputs (+5 volts = logic 1.)(You can use SPDT switches to make sure that the simulation is compatible with previous versions of Multisim.)
5. Label the switches (0-7) (and use the keys (0-7) to turn them on and off. Turn off the switches (logic 0).
6. Save your work.

Question:

1. In your journal, create a table with the binary values and the output voltage.
2. Investigate the VDAC by changing the switches. Which switch input controls the LSB (hint: the LSB is D0)? Which controls the MSB? Enter your table number of values, to illustrate the workings of the VDAC.
3. Try the following entries (in binary): 0, 1, 2, 3, 114,115,116,117, 253, 254, and 255. (Try any others that you wish, also.) What is the basic step size? What is the smallest output voltage? What is the largest output voltage?

4. TASK 4: ADC

1. Attach the 8-bit counter from task 2 to your VDAC in task 3. (Remove the 8 switches.)
2. Attach a digital clock signal generator (or function generator set correctly) to the 8-bit clock (replacing the single-step switch.)
3. Remove the voltmeter at the DAC-V output and replace it with a scope.

Question:

1. Run the simulation and draw a sketch of what you see. How many steps are there?
2. Change the reference voltage and observe the change in the output of the DAC-V.
3. A counter-comparator A/D process uses a counter and D/A circuit as investigated in Task4. A comparator can be added along with other control circuitry to build an A/D. The basic circuit is shown in the figure above. Explain the operation of this circuit, and using your findings, predict what 8-bit word would result for 4.5-volt analog input. Assume a 10-volt reference circuit. (Note: consider what step size you found and calculate how many steps are needed to become larger than 4.5 volts.)

5. Laboratory Report

No later than 7 days from the starting time of your lab section, provide the TA a hard copy of a lab report following the CENG 3311 Lab report Template given on the Black Board. You can write it down in the lab book or include your report in the lab book. Each student will submit one lab report to the TA. Your report should have the reporting requirements needed for all tasks. **The TA will take off a significant number of points if you does not follow the lab template.**

6. GRADING POLICY

1. Completion of Task 1 with results included in a lab report (15%)
2. Completion of Task 2 with results included in a lab report (25%)
3. Completion of Task 3 with results included in a lab report (25%)
4. Completion of Task 4 with results included in a lab report (25%)
5. Completeness, quality, and correctness of the lab report (10%)