Total Energy Consumption for Write from Four Proposed Circuit Designs

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***Abstract*—**The purpose of this project is to find the user inputted word within the text and count the number of times it appears in a string regardless of case sensitivity. This paper looks at four different circuit designs with four different write energy. They are then analyzed to determine which of these designs would have the best total energy consumption. Three tests were performed using a different word in each cases. The words chosen are *kNiGhT*, *ucf*, and *IT*. The outputs calculated each word regardless of case sensitivity. The beset total energy consumption performed in this project is design 3 with the least total energy consumed being 15888 fJ.

Keywords*—SRAM, Non-Volatile Memory, SDRAM, ALU*

I. Program Design

A text is given to the students in order to create a string to analyze and display an output with a counter. The program asks the user to enter a word, and along with that word, the output should display the number of times the word appears in the text. Also, the program should count the word regardless of the case sensitivity, so if the user enters a word with upper and lower case simultaneously, the word should still be analyzed and counted despite of having either upper or lower case.

The three inputs that were chosen for the tests are *kNiGht*, *ucf*, and *IT*. The reason behind these three choices is that for *kNiGhT* was chosen to test if a mixture of uppercase and lower case letters would be counted by the program. The word *ucf* was chosen with all lowercase letters to test if any UCF word would be counted since all of the UCF words in the string are uppercase. *IT* was chosen in all uppercase letters because the string only contains that word in lowercase letters. The outputs counted all the letters pertaining to the inputted words regardless of the case sensitivity.

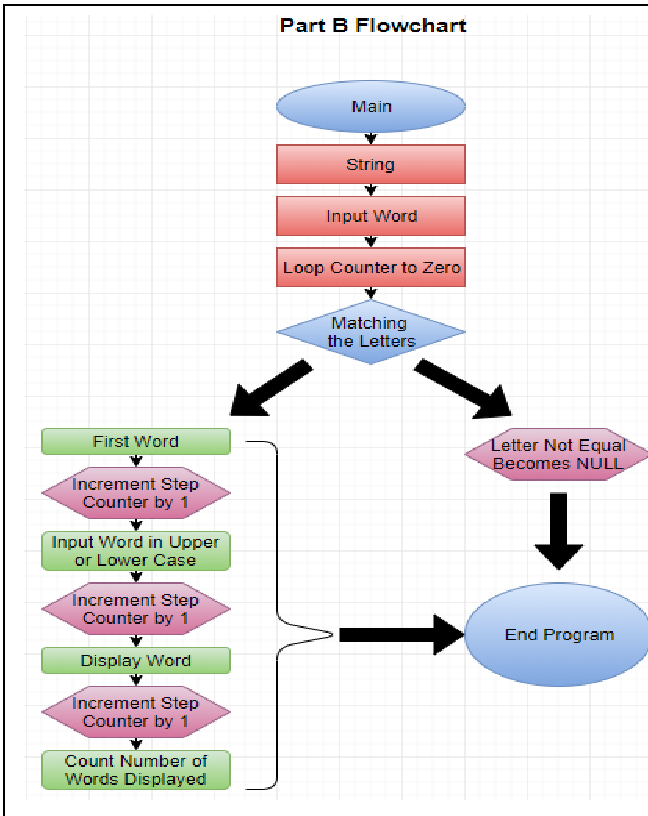

Fig.1: Flowchart of the assembly program.

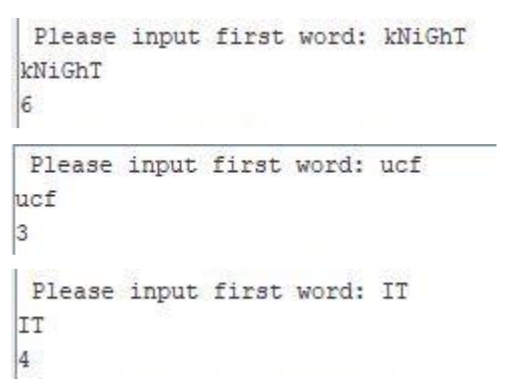

Fig.2: Sample outputs of the assembly program.

II. MEMORY BIT-CELLS

The overall goal of the researches done by the references being used is to minimize the switching currents at the same time by keeping the necessary nonvolatility according to [2]. In general, Spin Hall Effect (SHE) is being utilized the most. This process have allowed longer device life as well as efficient spin generation for the read and write paths. On top of this, this process have been combined with magnetic tunnel junctions (MTJ) to become even more attractive in recent years. MTJ is a CMOS alternative regarding logic and memory.

SHE-MTJ has great advantages including the circuit having less transistor geometry while still upholding the symmetric behavior. As mentioned in [1], though the currents for write are lower, an additional nMOS transistor is added to increase the write speed. This improves the overall write quality while having less transistors, making technologies perform better.

Bit-line and word-line are connected and intertwined to each other. According to [5], a bit decoder and word decoder are coupled to the bit lines and word lines. Basically, the way some chips, such as SDRAM, are structured, the rows are called word-line and the colums are known as bit-lines. They are gate-contact lines which are array segments.

III. RESULTS AND DISCUSSION

In this section, you are tasked to calculate the energy consumption of your program using the below energy consumption per instruction values:

1) *ALU = 1 fJ*
2) *Branch = 3 fJ*
3) *Jump = 2 fJ*
4) *Memory = Read Energy (1 fJ) + Write Energy (Refer to Table I)*
5) *Other = 5 fJ*

Table I: Energy consumption for a single bit-cell write operation in the designs provided in [1-4].

Design	Energy Consumption For Each ALU Instruction
[1]	360 fJ
[2]	300 fJ
[3]	280 fJ
[4]	420 fJ

Using the energy values mentioned above and the dynamic instruction count obtained by going to **MARS4.5➔Tools➔Instruction Statistics**, the total energy consumption is able obtained. The calculations used the values mentioned previously incorporated in the formula: Total Energy Consumption = (ALU x ALU Instructions) + (Branch x Branch Instructions) + (Jump x Jump Instructions) + (Memory x Memory Instructions) + (Other x Other Instructions)

Table II: Total Energy consumption for the assembly program using designs provided in [1-4].

Design	Total Energy Consumption
[1]	15968 fJ
[2]	15908 fJ
[3]	15888 fJ
[4]	16028 fJ

Using the data obtained from the instruction statistics from Mars Mips and the energy consumption values, the word *kNiGhT* displayed the above results for the four circuit designs. It appears design [3] have the least energy consumption, thus making it the better of them all. Design [4] turned up to be the most energy consumed. However, all the designs displayed a good total energy consumption rate overall.

IV. CONCLUSION

The trends I observed in this research is that write current and speed are being improved drastically as time passes. One of the most popular concepts catching attention is the spin hall effect based magnetic tunnel junctions. With time, less transistors are being utilized while maintaining or even improving performance including write current. Another trend I have witnessed is that Moore's Law is holding true. Perhaps we will reach a point where the transistors will be super tiny and speed of write capabilities will skyrocket to where it will become unnecessary to improve write current any longer. The total consumption of the best design analyzed in this project is the design from [3]. The energy consumption was far less than the other competitors.

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