Week 6-7 - Lesson 2.3 - Date of Birth Design Problem

**Preface**

Engineering is not about completing step-by-step activities or even mid-size projects where the outcome is predefined. Engineering is about solving problems and engaging in a distinct process in order to do so.

Though this lesson includes few new concepts and is relatively short in duration, completion of this lesson requires an understanding of knowledge and concepts learned earlier in this unit. Student will gain first-hand design experience by transferring their prior knowledge as they transform a design from written specifications to circuit implementation.

In this lesson students will learn how to utilize a seven-segment display to show alpha/numeric values. Students will design a large combinational logic circuit, with multiple outputs, that will display their individual date of birth. The implementation of this logic circuit will require the use of NAND, NOR, and AOI logic.

**Concepts**

1.      Seven-segment displays are used to display the digits 0-9 as well as some alpha characters.

2.      The two varieties of seven-segment displays are common cathode and common anode.

3.      Any combinational logic expression can be implemented with AOI, NAND, or NOR logic.

4.      A formal design process exists for translating a set of design specifications into a functional combinational logic circuit.

**Standards and Benchmarks Addressed**

***Standards for Technological Literacy***

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| **Standard 2:  Students will develop an understanding of the core concepts of technology.** |
| **BM Z:** | Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.  |
| **BM AA:** | Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.  |
| **BM BB:** | Optimization is an on going process or methodology of designing or making a product and is dependent on criteria and constraints. |
| **BM DD:** | Quality control is a planned process to ensure that a product, service, or system meets established criteria.  |
| **Standard 8:  Students will develop an understanding of the attributes of design.**  |
| **BM I:** | Design problems are seldom presented in a clearly defined form.  |
| **BM J:** | The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.   |
| **BM K:** | Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. |
| **Standard 9:  Students will develop an understanding of engineering design.**  |
| **BM J:** | Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. |
| **BM L:** | The process of engineering design takes into account a number of factors. |
| **Standard 11:  Students will develop abilities to apply the design process.** |
| **BM N:** | Identify criteria and constraints and determine how these will affect the design process.   |
| **BM O:** | Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.   |
| **BM P:** | Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.   |
| **BM Q:** | Develop and produce a product or system using a design process.    |
| **BM R:** | Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. |
| **Standard 12:  Students will develop the abilities to use and maintain technological products and systems.**  |
| **BM M:** | Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it. |
| **BM N:** | Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision.  |
| **BM O:** | Operate systems so that they function in the way they were designed.  |
| **Standard 17:  Students will develop an understanding of and be able to select and use information and communication technologies.**  |
| **BM L:** | Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information. |
| **BM M:** | Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine.  |
| **BM N:** | Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate.  |
| **BM O:** | Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. |
| **BM P:** | There are many ways to communicate information, such as graphic and electronic means. |
| **BM Q:** | Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. |

***National Science Education Standards***

**Science as Inquiry Standard A:** As a result of activities in grades 9-12, all students should develop

         Abilities necessary to do scientific inquiry

         Understandings about scientific inquiry

**Science and Technology Standard E:** As a result of activities in grades 9-12, all students should develop

         Abilities of technological design

         Understandings about science and technology

***Principle and Standards for School Mathematics***

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| **Number and Operations:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to compute fluently and make reasonable estimates. |
| **Algebra:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to understand patterns, relations, and functions, represent and analyze mathematical situations and structures using algebraic symbols, use mathematical models to represent and understand quantitative relationships, and analyze change in various contexts. |
| **Problem Solving:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to build new mathematical knowledge through problem solving, solve problems that arise in mathematics and in other contexts, apply and adapt a variety of appropriate strategies to solve problems, and monitor and reflect on the process of mathematical problem solving |
| **Reasoning and Proof:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to recognize reasoning and proof as fundamental aspects of mathematics, make and investigate mathematical conjectures, and select and use various types of reasoning and methods of proof. |
| **Connections:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to recognize and apply mathematics in contexts outside of mathematics. |
| **Number and Operations:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to compute fluently and make reasonable estimates. |
| **Communication:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to communicate their mathematical thinking coherently and clearly to peers, teachers, and others. |

***Standards for the English Language Arts***

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| **Standard 4:** | Students adjust their use of spoken, written, and visual language (e.g. conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. |

**Performance Objectives**

*It is expected that students will:*

         Use a seven-segment display in a combinational logic design to display alpha/numeric values.

         Select the correct current limiting resistor and properly wire both common cathode and common anode seven-segment displays.

         Follow a formal design process to translate a set of design specifications for a design containing multiple outputs into a functional combinational logic circuit.

         Design AOI, NAND, & NOR solutions for a logic expression and select the solution that uses the least number of ICs to implement.

         Use Circuit Design Software (CDS) and Digital Logic Board (DLB) to simulate and prototype AOI, NAND, & NOR logic circuits.

**Assessment**

*Explanation*

         Students will explain why design options of a project are determined by criteria and constraints.

*Application*

         Students will demonstrate and explain to another student how their date of birth problem works.

*Empathy*

         Students will discuss in their engineering notebook concerns they may have for the environment regarding electronic components.

**Essential Questions**

1.      What is the relationship between the resistor value used, the amount of current flowing, and the brightness of a segment of seven-segment display.

2.      Why is it more difficult to design logic circuits with NAND logic or NOR logic than it is with straightforward AOI logic, in terms of circuit implementation.

3.      Why does a logic expression require fewer ICs to implement if NAND logic or NOR logic is used than would be required if AOI logic were used.

4.      What are the steps in the design process of converting a set of design specifications, containing multiple outputs, into a functional combinational logic circuit?

5.      When compared to a design with a single output, is the process different for multiple outputs? Explain.

**Key Terms**

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| **Common Anode Display** | A seven-segment LED display where the anodes of all the LEDs are connected to the circuit supply voltage. Each segment is illuminated by a logic LOW at its cathode. |
| **Common Cathode Display** | A seven-segment display in which the cathodes of all the LEDs are connected together and grounded. A logic HIGH illuminates a segment when applied to its anode.  |
| **Datasheet** | A printed specification giving details of the pin configuration, electrical properties, and mechanical profile of an electronic device. |
| **Design Specifications** | A detailed description, especially one providing information needed to make, build, or produce something.  |
| **Seven-Segment Display** | An array of seven independently controlled light-emitting diodes (LED) or liquid crystal display (LCD) elements, shaped like a figure 8, which can be used to display decimal digits and other characters by turning on the appropriate elements. |

**Day-by-Day Plans**

*Time: 9 days*

**Day 1: Seven-Segment Displays**

         The teacher will present **Concepts**, **Essential Questions**, and **Key Terms** in order to provide a lesson overview.

         The teacher will present **Seven-Segment Displays**.**ppt**.

         Students will take notes in their engineering journals.

         The teacher will distribute and introduce **Activity 2.3.1 Seven-Segment Displays**.

         Students will work on Activity 2.3.1 Seven-Segment Displays.

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 **Day 2 – 9: Date of Birth Design Problem**

         The teacher will review the *Combinational**Logic Design Process (v1)* flow chart.

         The teacher will present **Date of Birth Design Problem**.**ppt**.

         Students will take notes in their engineering journals.

         The teacher will distribute and introduce **Problem 2.3.2 Date of Birth****.**

         Assessed by completion of working date of birth

         Students will work on Problem 2.3.2 Date of Birth.

         The teacher will assist the students as needed.

**Instructional Resources**

Presentations

**Seven-Segment Displays**

**Date of Birth Design Problem**

Word Documents

**Activity 2.3.1 Seven-Segment Displays**

**Problem 2.3.2 Date of Birth**