Lesson 3.2 Asynchronous Counters

**Preface**

Digital design applications that necessitate the ability to count are numerous. These counting applications range from the simple *Now Serving* sign at the neighborhood deli counter to the countdown display used by NASA to launch rockets. A number of techniques are used to design counters, but they all fall into two general categories, each with their own advantages and disadvantages. These two categories are called asynchronous counters and synchronous counters.

Asynchronous counters will be the topic of study of this lesson. The primary design characteristic of asynchronous counters that distinguish them from synchronous counters is that the flip-flop of each stage is clocked by the flip-flop output of the prior stage. Thus, rather than all the flip-flops changing simultaneously, the clock ripples its way from the first flip-flop to the last. This is why asynchronous counters are sometimes referred to as ripple counters.

After completing a series of activities on the process for designing SSI and MSI asynchronous counters, this lesson will conclude with a design problem that requires the students to design and simulate a sixty-second timer. The specifications for this timer are such that the students are required to utilize both the SSI and the MSI design techniques in their solution.

**Concepts**

1.      Asynchronous counters, also called ripple counters, are characterized by an external signal clocking the first flip-flop. All subsequent flip-flips are clocked by the output of the previous flip-flop.

2.      Asynchronous counters can be implemented using small scale integrated (SSI) and medium scale integrated (MSI) logic gates.

3.      Asynchronous counters can be implemented with either D or J/K flip-flops.

4.      Up counters, down counters, and modulus counters all can be implemented using the asynchronous counter method.

**Standards and Benchmarks Addressed**

***Standards for Technological Literacy***

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| **Standard 3:** | Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study. |
| **BM E:** | A product, system, or environment developed for one setting may be applied to another setting. |
| **BM F:** | Knowledge gained from other fields of study has a direct effect on the development of technological products and systems. |
| **BM G:** | Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function |
| **BM H:** | Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. |
| **BM J:** | Technological progress promotes the advancement of science and mathematics. Likewise, progress in science and mathematics leads to advances in technology. |
| **Standard 6:** | Students will develop an understanding of the role of society in the development and use of technology. |
| **BM F:** | Social and cultural priorities and values are reflected in technological devices. |
| **BM G:** | Meeting societal expectations is the driving force behind the acceptance and use of products and systems. |
| **BM H:** | Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and values. |
| **BM I:** | The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. |
| **BM J:** | A number of different factors, such as advertising, the strength of the economy, the goals of a company and the latest fads contribute to shaping the design of and demand for various technologies. |
| **Standard 7:** | Students will develop an understanding of the influence of technology on history. |
| **BM H:** | The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials. |
| **BM I:** | Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape. |
| **BM J:** | Early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how. |
| **Standard 9:** | Students will develop an understanding of engineering design. |
| **BM H:** | Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. |
| **BM I:** | Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. |
| **BM J:** | Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. |
| **Standard 10:** | Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. |
| **BM F:** | Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system. |
| **BM H:** | Some technological problems are best solved through experimentation. |
| **BM L:** | Many technological problems require a multidisciplinary approach. |
| **Standard 12:** | Students will develop the abilities to use and maintain technological products and systems. |
| **BM H:** | Use information provided in manuals, protocols, or by experienced people to see and understand how things work. |
| **BM I:** | Use tools, materials, and machines safely to diagnose, adjust, and repair systems. |
| **BM K:** | Operate and maintain systems in order to achieve a given purpose. |
| **BM L:** | Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. |
| **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. |
| **BM P:** | Use computers and calculators to access, retrieve, organize and process, maintain, interpret, and evaluate data and information in order to communicate. |

***National Science Education Standards***

**Standard K-12: Unifying Concepts and Processes:**  As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes;

         Systems, order, and organization

         Evidence, models, and explanation

         Change, constancy, and measurement

         Form and function

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

         Abilities necessary to do scientific inquiry

         Understandings about scientific inquiry

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

         Abilities of technological design

         Understandings about science and technology

**Standard F: Science in Personal and Social Perspectives:** As a result of activities in grades 9-12, all students should develop understanding of;

         Science and technology in local, national, and global challenges

**Standard G: History and Nature of Science:** As a result of activities in grades 9-12, all students should develop understanding of;

         Science as a human endeavor

         Nature of scientific knowledge

         Historical perspectives

***Principles 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; understand numbers, ways of representing numbers, relationships among numbers, and number systems; understand meanings of operations and how they relate to one another; 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; analyze change in various contexts. |
| **Measurement:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to; understand measurable attributes of objects and the units, systems, and processes of measurement; apply appropriate techniques, tools, and formulas to determine measurements. |
| **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; monitor and reflect on the process of mathematical problem solving. |
| **Communication:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to; organize and consolidate their mathematical thinking through communication; communicate their mathematical thinking coherently and clearly to peers, teachers, and others; analyze and evaluate the mathematical thinking and strategies of others; use the language of mathematics to express mathematical ideas precisely. |
| **Connections:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to; recognize and use connections among mathematical ideas; understand how mathematical ideas interconnect and build on one another to produce a coherent whole; recognize and apply mathematics in contexts outside of mathematics. |
| **Representation:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to; create and use representations to organize, record, and communicate mathematical ideas; select, apply, and translate among mathematical representations to solve problems; use representations to model and interpret physical, social, and mathematical phenomena. |

***Standards for English Language Arts***

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| **Standard 3:** | Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and other texts, their word identification strategies, and their understanding of textual features (e.g. sound-letter correspondence, sentence structure, context, graphics). |
| **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. |
| **Standard 12:** | Students use spoken, written and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information). |

**Performance Objectives**

*It is expected that students will:*

         Know the advantages and disadvantage of counters designed using the asynchronous counter method.

         Be able to describe the ripple effect of an asynchronous counter.

         Be able to analyze and design up, down and modulus asynchronous counters using discrete D and J/K flip-flops.

         Be able to analyze and design up, down and modulus asynchronous counters using medium scale integrated (MSI) circuit counters.

**Essential Questions**

1.      What is another name for an Asynchronous counters?

2.      How are the clock inputs of an asynchronous counter’s flip-flops connected?

3.      What is the process for designing asynchronous counters implemented using discrete D and J/K flip-flops and medium scale integrated (MSI) circuit counters?

4.      What is the process for designing up, down and modulus asynchronous counters?

**Key Terms**

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| **Asynchronous Counter** | Type of counter in which each flip-flop output serves as the clock input signal for the next flip-flop in the chain. |
| **Binary Counter** | Group of flip-flops connected in a special arrangement in which the states of the flip-flops represent the binary number equivalent to the number of pulses that have occurred at the input of the counter. |
| **Decade Counter** | Any counter capable of going through 10 different logic states. |
| **Down Counter** | Counter that counts from a maximum count downward to 0. |
| **Modulus** | The number of states through which a counter sequences before repeating. |
| **Modulus N Counter**  **(mod-n counter)** | A counter with a modulus of N. |
| **Synchronous Counter** | Counter in which all of the flip-flops are clocked simultaneously. |
| **Up Counter** | Counter that counts upward from 0 to a maximum count. |
| **Up/Down Counter** | Counter that can count up or down depending on how its inputs are activated. |

**Day-by-Day Plans**

*Time: 5 days*

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**Day 1 – 2: Lesson Overview and Introduction to Asynchronous Counters**

         The teacher will present [**Concepts**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Unit_3/L3_2AsynchronousCounters.htm#concepts), [**Essential Questions**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Unit_3/L3_2AsynchronousCounters.htm#questions), and [**Key Terms**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Unit_3/L3_2AsynchronousCounters.htm#terms) in order to provide a lesson overview.

         The teacher will present [**Asynchronous Counters w/SSI Logic.ppt.**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Powerpoints/AsynchronousCountersSSI.ppt)

         Students will take notes in their engineering notebooks/portfolios.

         The teacher will distribute and introduce [**Activity 3.2.1 SSI Asynchronous Counters.**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Unit_3/Activities/A3_2_1SSIAsynchronousCounters.htm)

         Students will take notes in their engineering notebooks/portfolios.

         Students will work on Activity 3.2.1 SSI Asynchronous Counters.

         The teacher will assist the students as needed.

         The teacher will present [**7-segment Display Driver.ppt.**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Powerpoints/SevenSegmentDisplayDriver.ppt)

         Students will take notes in their engineering journals.

         The teacher will distribute and introduce [**Activity 3.2.2 SSI Asynchronous Modulus Counters.**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Unit_3/Activities/A3_2_2SSIAsynchronousModulusCounters.htm)

         Students will take notes in their engineering notebooks/portfolios.

         Students will work on Activity 3.2.2 SSI Asynchronous Modulus Counters.

**Day 3 – 5: MSI Asynchronous Counters**

         The teacher will present [**Asynchronous Counters w/MSI Logic.ppt.**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Powerpoints/AsynchronousCountersMSI.ppt)

         Students will take notes in their engineering notebooks/portfolios.

         The teacher will distribute and introduce [**Activity 3.2.4 MSI Asynchronous Counters.**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Unit_3/Activities/A3_2_4MSIAsynchronousCounters.htm)

         Students will work on Activity 3.2.4 MSI Asynchronous Counters.

         The teacher will introduce [**Problem 3.2.4 Sixty Second Timer**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Unit_3/Activities/P3_2_4SixtySecondTimer.htm).

         Students will complete [**Problem 3.2.4 Sixty Second Timer**](mk:@MSITStore:C:\Documents%20and%20Settings\ghzite\Desktop\AE_2009.chm::/Unit_2/Activities/OptActivity2_1_6Pitot_Tubes.htm).

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**Instructional Resources**

Presentations

[**Asynchronous Counters w/SSI Logic**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Powerpoints/AsynchronousCountersSSI.ppt)

[**Asynchronous Counters w/MSI Logic**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Powerpoints/AsynchronousCountersMSI.ppt)

[**7-segment Display Driver**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Powerpoints/SevenSegDisplays.ppt)

Word Documents

[**Activity 3.2.1 SSI Asynchronous Counters**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Unit_3/Activities/A3_2_1SSIAsynchronousCounters.doc)

[**Activity 3.2.2 SSI Asynchronous Modulus Counters**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Unit_3/Activities/A3_2_2SSIAsynchronousModulusCounters.doc)

[**Activity 3.2.3 PLD Asynchronous Counter Design**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Unit_3/Activities/A3_2_3PLDAsynchronousCounterDesign.doc)

[**Activity 3.2.4 MSI Asynchronous Counters**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Unit_3/Activities/A3_2_4MSIAsynchronousCounters.doc)

[**Problem 3.2.4 Sixty Second Timer**](mk:@MSITStore:C:\Documents%20and%20Settings\DAVID_ROEMER\Desktop\DE\DE_2009.chm::/Unit_3/Activities/P3_2_4SixtySecondTimer.doc)