College, Career and Technical Education

Published for 2020-21 school year.

Digital Electronics

Primary Career Clusters:	Advanced Manufacturing Science, Technology, Engineering, and Mathematics (STEM)
Course Contact:	CTE.Standards@tn.gov
Course Code(s):	C13H07
Pre-requisite(s):	*Algebra I* (G02X02, G02H00)
Credit:	1
Grade Level:	10
Focus Elective Graduation Requirement:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Advanced Manufacturing or *STEM* courses.
Program of Study (POS) Concentrator:	This course satisfies one out of two required courses that meet the Perkins V concentrator definition, when taken in sequence in the approved program of study.
Programs of Study and Sequence:	This is the second course in the *Mechatronics* and *Technology* programs of study.
Aligned Student Organization(s):	SkillsUSA: http://www.tnskillsusa.com Technology Student Association (TSA): http://www.tntsa.org
Coordinating Work-Based Learning:	Teachers are encouraged to use embedded WBL activities such as informational interviewing, job shadowing, and career mentoring. For information, visit https://www.tn.gov/education/career-and-technical-education/work-based-learning.html
Available Student Industry Certifications:	Students are encouraged to demonstrate mastery of knowledge and skills learned in this course by earning the appropriate, aligned department-promoted industry certifications. Access the promoted list here for more information.
Teacher Endorsement(s):	013, 014, 015, 016, 017, 018, 047, 070, 078, 081, 125, 126, 127, 128, 129, 157, 210, 211, 212, 213, 214, 230, 231, 232, 233, (042 and 043), (042 and 044), (042 and 045), (042 and 046), (042 and 047), (042 and 077), (042 and 078), (042 and 079), (043 and 044), (043 and 045), (043 and 046), (043 and 047), (043 and 077), (043 and 078), (043 and 079), (044 and 045), (044 and 046), (044 and 047), (044 and 077), (044 and 078), (044 and 079), (045 and 046), (045 and 047), (045 and 077), (045 and 078), (045 and 079), (046 and 047), (046 and 077), (046 and 078), (046 and 079), (047 and 077), (047 and 078), (047 and 079), (077 and 078), (077 and 079), (078 and 079), 413, 414, 415, 416, 417, 418, 449, 470, 477, 501, 502, 519, 523, 531, 537, 551, 552, 553, 554, 555, 556, 557, 567, 575, 582, 584, 585, 595, 596, 598, 700, 701, 705, 707, 740, 760, 982
Required Teacher Certifications/Training:	Some endorsements require NIMS industry certification to teach this course. Please refer to the correlation of course codes for a full list.

Teacher Resources:	https://www.tn.gov/education/career-and-technical-education/career-clusters/cte-cluster-advanced-manufacturing.html https://www.tn.gov/education/career-and-technical-education/career-clusters/cte-cluster-stem.html

Course Description

Digital Electronics is intended to provide students with an introduction to the basic components of digital electronic systems and equip them with the ability to use these components to design more complex digital systems. Proficient students will be able to (1) describe basic functions of digital components (including gates, flip flops, counters, and other devices upon which larger systems are designed), (2) use these devices as building blocks to design larger, more complex circuits, (3) implement these circuits using programmable devices, and (4) effectively communicate designs and systems. Students develop additional skill in technical documentation when operating and troubleshooting circuits. Upon completion of the *Digital Electronics* course, proficient students will be able to design a complex digital system and communicate their designs through a variety of media.

Program of Study Application

This is the second course in the *Mechatronics* and *Technology* programs of study. For more information on the benefits and requirements of implementing these programs in full, please visit the Advanced Manufacturing and STEM websites at https://www.tn.gov/education/career-and-technical-education/career-clusters/cte-cluster-advanced-manufacturing.html and https://www.tn.gov/education/career-and-technical-education/career-clusters/cte-cluster-stem.html

Course Standards

Safety

1) Accurately read, interpret, and demonstrate adherence to safety rules including (1) rules published by the National Science Teachers Association (NSTA), (2) rules pertaining to electrical safety, (3) Occupational Safety and Health Administration (OSHA) guidelines, and (4) state and national code requirements. Be able to distinguish between the rules and explain why certain rules apply.

2) Identify and explain the intended use of safety equipment available in the classroom. For example, demonstrate how to properly inspect, use, and maintain safe operating procedures with tools and equipment.

Citizenship and Career Exploration

3) In teams, develop a persuasive paper or presentation arguing for the importance of electrical and/or computer engineers' contributions to society. Select several such contributions as justification, and provide compelling evidence for how electrical/computer engineers' designs are used in everyday applications. Incorporate a variety of sources to gather data, including print and electronic; cite each source, and briefly describe why the particular source is reliable.

4) Research the postsecondary institutions in Tennessee that offer electrical engineering or electrical and/or computer engineering technology. Individually or in teams, develop and publish

information that identifies admissions criteria, the postsecondary programs of study, and the secondary courses that will prepare students for success after high school in electrical or computer engineering fields. Cite each source adhering to standard citation conventions used in engineering disciplines.

Gates in Logic Circuits

5) Identify each type of logic gate with a drawing, a description of its function in a short sentence or paragraph, a specification of each truth table, and the equation for each gate (buffer, inverter, AND, NAND, OR, NOR, XOR [difference], and XNOR [equivalence]), including the valid number of input(s) and output(s) for each gate.

6) Define D and JK flip flops by including a drawing, a description of the function in a short sentence or paragraph, and a specification of each truth table and equation. The description should explain how the "clock" signal is related to the flip flop.

7) In teams, design three (or more) combinational (without a clock signal) devices to a scale that would be typically implemented in a medium-scale integrated circuit (MSI: typically 10-1000 gates). One of the devices should incorporate XOR / XNOR gates. Examples of devices include 4-bit or greater versions of the following: adder/subtractor, comparator, multiplexer, and calculator. Upon completion of the design, develop a technical presentation providing an overview of the device and its specifications, an accompanying schematic, and a list of the gates used. Present the project to classmates and refine the presentation based on their feedback.

8) Working in teams, develop and publish information detailing a rich description of one of the combinational projects, and including a schematic and summary of test results If a prototyping system is available in the classroom (Xilinx, Altera, or similar), physically test the project and report results. If possible, include a video of the test. Present the project to the class, and revise based on peer feedback.

9) Design a counter with up to 32 states and write an explanatory text describing how the counter operates using technical and domain-specific vocabulary. Provide a state diagram and draw a schematic for the circuit using D or JK flip flips.

Counters in Logic Circuits

10) In teams, design two (or more) sequential devices that utilize a counter. For example, design a traffic light system with two turn arrows. Create a poster presentation that could be shown at a science fair or career and technical student organization (CTSO) with a description of the device, an accompanying schematic, and a list of the gates used.

Oscillators in Logic Circuits

11) In teams, design a clock signal using a 555-timer in an astable monovibrator configuration. Simulate the design and/or build a prototype and measure the output frequency. If instrumentation to measure the frequency is not available (an oscilloscope for example), a clock frequency timed using a stopwatch can be used as an alternative. Compare and contrast the prediction of the outcome with actual results. Develop a presentation to explain the circuit design,

the prediction, and the results from the simulation or prototype. *Note: The instructor may wish to constrain the output frequency by supplying a resistor value and/or a capacitor value.*

12) In teams, design a counter with between 16 and 32 states. Clock the counter using an oscillator of known frequency, and predict the frequency from each output (each bit in the counter). Simulate the counter to verify the prediction. If possible, the counter should be physically prototyped to verify the prediction and simulation. Calculate the error between the prediction and simulation or prototype. Produce a technical report to summarize findings.

Multiplexers in Signal Distribution

13) Design a circuit with 4-8 signals and use a multiplexer to select one of the signals as the output, then simulate the circuit. Develop and deliver a presentation describing the inputs, explaining the circuitry used to select the channel to output, and featuring a timing diagram illustrating the successful operation of the circuit.

14) In teams, design a 4-channel multiplexer using gates. Simulate or build a prototype of the circuit, and demonstrate it to the class. Participate in a class discussion that compares and contrasts the various designs exhibited. As a class, determine the best design and provide supporting evidence from observations and functionality to justify the decision.

Functions of Analog and Digital Convertors

15) In teams, design a circuit using an A/D converter to measure the temperature in the room. Specify the assumptions made for minimum and maximum temperatures, and calculate the resolution (step) of the system. Upon completion of the circuit, write a technical specification of the design; then present the design and technical specifications to the class, including a graph showing the input and output values. Using the feedback from classmates, write a summary describing how the design could be revised and improved in future projects. *Note: Instructors may substitute a similar project in which a continuous and limited quantity is measured.*

16) Using multiple print and digital sources, research the uses for A/D and D/A converters in a current technical device. For example, describe how data acquisition systems in race cars use A/D and D/A converters. Draw on the research findings to develop talking points and participate in a mock public forum on the uses for A/D and D/A converters.

Program Microcontrollers

17) Sketch and describe a block diagram of a computer system, detailing at least the following components:
    a. Microcontroller / microprocessor
    b. Cache
    c. RAM (Random Access Memory)
    d. Large-scale memory
    e. Input devices
    f. Output devices (monitor[s])

Show the proper connections between each component, such as data bus and address bus connections. Using visual aids, present and explain the block diagram to the class.

18) In teams, program a microcontroller-based system to perform a series of tasks. The microcontroller should be part of a larger system. Upon completion of the programming, write a technical report summarizing the functions and intended uses of the end product. Include the specifications of the series of tasks performed by the microcontroller and the programming code with comments for each function. Present the design to the class, and revise the report based on feedback from peers.

Technical Documentation and Troubleshooting

19) Consult technical documents (such as data sheets, timing diagrams, operating manuals, and schematics) of digital components (TTL, CMOS, etc.) to develop a troubleshooting methodology for a digital circuit that could be used by a new technician. Create and deliver a presentation demonstrating the troubleshooting procedure for the class.

Projects

20) In teams, identify a problem requiring a digital circuit (including A/D, D/A conversion and/or a microprocessor). Follow the design process to solve the problem using digital electronics. Develop a written report documenting the solution, including a background section describing the problem which cites written or electronic sources and documentation of each stage in the design process. Build a prototype proof-of-concept if feasible. Present the problem, the design process used, and the developed solution to the class and other technical or non-technical audience members (e.g., parents, teachers, school administrators, STEM professionals, etc.). The final report draft should be critiqued by a different student team or outside expert. Thereafter, incorporate feedback to refine the report and submit a final version.

Standards Alignment Notes

*References to other standards include:

- P21: Partnership for 21st Century Skills [Framework for 21st Century Learning]
    - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.