Digital Logic Analysis

Mechanical and Transportation Technology

Course Number: ELN8303	**Contribution to Program:** Vocational		**Normative Hours:** 135
Applicable Program(s): 0550X01FWO EME Technician - Robotics	**AAL:** 3	**Core/Elective:** Core	**Approval Date:** 21/06/2013
Prepared by: Stephen Ryan Coordinator			**Approved by:** Misheck Mwaba, PhD., P.Eng. Chair, Mechanical and Transportation Technology
Co-Requisites N/A			**Approved for Academic Year:** 2013-2014
Pre-Requisites ELN9192			

COURSE DESCRIPTION

The theory of digital logic, including number systems is covered. Topics of study include logic gates and Boolean algebra, the introduction to PLD's, sequential logic, combinational logic, flip-flops, counters and shift registers. Using lab experiments, students learn to design and apply modern digital circuitry.

RELATIONSHIP TO VOCATIONAL LEARNING OUTCOMES

This course contributes to your program by helping you achieve the following Vocational Learning Outcomes:

EME Technician - Robotics 0550X01FWO

2	Interpret and produce electrical, electronic, and mechanical drawings and other related documents and graphics to appropriate engineering standards.(T,A,CP)
3	Select and use a variety of troubleshooting techniques and test equipment to assess electromechanical circuits, equipment, processes, systems, and subsystems.(T,A,CP)
4	Modify, maintain, and repair electrical, electronic, and mechanical components, equipment, and systems to ensure that they function according to specifications.(T,A,CP)
5	Apply the principles of engineering, mathematics, and science to analyze and solve routine technical problems and to complete work related to electromechanical engineering.(T,A,CP)
7	Analyze, build, and troubleshoot logic and digital circuits, passive AC and DC circuits, and active circuits.(T,A,CP)
14	Perform all work in accordance with relevant law, policies, codes, regulations, safety procedures, and standard shop practices. (T,A,CP)
15	Develop personal and professional strategies and plans to improve job performance and work relationships with clients, coworkers, and supervisors.(A)

T: Teach **A:** Assess **CP:** Culminating Performance

ESSENTIAL EMPLOYABILITY SKILLS

The course contributes to your program by helping you achieve the following Essential Employability Skills:

2	Respond to written, spoken or visual messages in a manner that ensures effective communication.(T,A,CP)
4	Apply a systematic approach to solve problems.(T,A,CP)
6	Locate, select, organize and document information using appropriate technology and information systems.(T,A,CP)
7	Analyze, evaluate and apply relevant information from a variety of sources.(T,A,CP)
10	Manage the use of time and other resources to complete projects.(T,A)
11	Take responsibility for one's own actions, decisions and consequences.(T,A,CP)

T: Teach **A:** Assess **CP:** Culminating Performance

COURSE LEARNING REQUIREMENTS/EMBEDDED KNOWLEDGE AND SKILLS

COURSE LEARNING REQUIREMENTS When you have earned credit for this course, you will have demonstrated the ability to:	EMBEDDED KNOWLEDGE AND SKILLS
1. Understand Basic Digital Concepts	ı Explain the basic difference between digital and analog qualities and their respective voltage levels ı Describe various parameters of a pulse waveform such as: rise time, pulse width, frequency, period and duty cycle ı Explain the basic logic operations of NOT, AND and OR ı Describe the logic functions of the comparator, adder, code converter, encoder, decoder, multiplexer, demultiplexer, counter and register ı Identify fixed-function digital integrated circuits according to their complexity and the type of circuit packaging
2. Understand and apply the operations, codes and conversions between the various number systems	ı Count in and apply arithmetic operations to the various number systems ı Convert between the various numbering systems ı Interpret the American Standard Code for Information Exchange (ASCII) ı Use binary numbers and codes in a system application
3. Design, test and program a PLD (Programmable Logic Device) to implement logic functions	ı Discuss PLD software ı Enter a logic design using PLD software then simulate the design and download it to a target device
4. Describe the operation of digital logic gates	ı Describe the operation of the following logic gates: the inverter, the AND, the OR, the NAND, the NOR, the XOR and the XNOR and express using Boolean Algebra ı Recognize and use both the distinctive shape logic symbols and the rectangular outline logic gate symbols of ANSI/IEEE Standard 91-1984 ı Construct timing diagrams showing the proper timing relationships of inputs and outputs for various logic gates ı Explain and make basic conversions between the major IC technologies CMOS and TTL ı Define propagation delay, power dissipation, speed-power product and fan-out in relation to logic gates ı List specific fixed function integrated circuit devices that contain the various logic gates ı Troubleshoot logic gates for opens and shorts by using the multimeter and oscilloscope ı Describe the basic concepts of programmable logic
5. Solve Boolean equations to find the minimum form	ı Apply the basic laws and rules of Boolean Algebra including DeMorgan's theorem ı Convert any Boolean expression into a sum-of-products (SOP) form and a product-of-sums (POS) form ı Use a Karnaugh map to simplify Boolean and truth table expressions and be able to explain and work with 'don't care' states ı Describe how a PAL (Programmable Array Logic) device works and explain how the part number defines its description
6. Define and create circuits using combinational logic	ı Analyze basic combinational circuits such as AND-OR, AND-OR-Invert, exclusive OR, exclusive NOR, and other general combinational networks and implement in sum-of-products (SOP) and product-of-sums (POS) expressions ı Develop the following for any combinational logic circuit: a Boolean expression, a truth table and a Karnaugh map ı Design a combinational logic circuit for a given Boolean output

	expression using various gates and be able to implement that given Boolean output expression using just NAND gates - Troubleshoot logic circuits by using signal tracing and waveform analysis - Describe a GAL and how it differs from a PAL
7. Describe the operation and application of binary and BCD counters, shift registers and other sequential logic circuits	- Distinguish between half-adders and full-adders - Use full-adders to implement multi-bit parallel binary adders - Explain the difference between ripple carry and look-ahead carry parallel adders - Use the magnitude comparator to determine the relationship between two binary numbers and use cascaded comparators to handle the comparison of larger numbers - Implement a basic binary, a BCD to 7-segment and a decimal to BCD decoder - Convert from binary to Gray code and Gray code to binary using logic devices - Apply multiplexers in data selection, multiplexed displays, logic functions generations and simple communication systems - Use decoders as multiplexers - Explain the meaning of parity and use parity generators and checkers to detect bit errors in digital systems - Use parity generators and checkers to detect bit errors in digital systems - Implement a simple data communications system - Identify glitches, common bugs in digital systems - Describe, basically, how SPLDs are programmed
8. Understand and apply the different flip flops and their related devices	- Use logic gates to construct basic latches - Explain the difference between an S-R latch and a D latch - Explain how S-R, D and JK flip flops differ - Explain how edge-triggered and master-slave flip flops differ - Recognize the difference between a latch and a flip flop - Understand the significance of propagation delays, set-up time, hold time, maximum operating frequency, minimum operating frequency, clock pulse widths and power dissipation in the application of flip-flops - Apply flip flops in basic applications - Analyse circuits for race conditions and the occurrence of glitches - Explain how retriggerable and non-retriggerable one-shots differ - Connect a 555 timer to operate as either an astable multivibrator or a one-shot - Approach the debugging of a new design - Troubleshoot basic flip-flop and one-shot circuits - Describe the OLMC's in the GAL22V10 and the GAL16V8 - Explain the difference between the registered mode and the combinational mode - Apply one-shots in a system application
9. Analyse and design various counters	- Describe the difference between an asynchronous and a synchronous counter - Analyse counter timing diagrams - Analyse counter circuits

	ı Explain how propagation delays affect the operation of a counter ı Identify and modify the modulus of a counter ı Recognize the difference between a 4-bit binary counter and a decade counter ı Use an up/down counter to generate forward and reverse binary sequences ı Determine the sequence of a counter ı Use IC counters in various applications ı Design a counter that will have any specified sequence of states ı Use cascaded counters to achieve a higher modulus ı Use logic gates to decode any given state of a counter ı Eliminate glitches in counter decoding ı Explain how a digital clock operates ı Troubleshoot counters for various types of faults ı Interpret counter logic symbols that use dependency notation ı Discuss mode selection in an SPLD
10. Recognize, analyse and design a number of shift registers	ı Explain how serial in/serial out, serial in/parallel out, parallel in/serial out and parallel in/parallel out shift registers operate ı Describe how a bidirectional shift register operates ı Determine the sequence of a ring and a twisted-ring (Johnson) counter using a shift register ı Use a shift register as a time delay device ı Implement a basic shift register controlled keyboard encoder ı Troubleshoot digital systems by "exercising" the system using a known test pattern ı Interpret ANSI/IEEE Standard 91-1984 shift register symbols with dependency notation ı Describe a basic CPLD

LEARNING RESOURCES

Text: Digital Fundamentals with PLD Programming, Thomas L. Floyd, Prentice-Hall
ISBN: 0-13-170188-6

Workbook: Experiments in Digital Fundamentals, 10e, David Buchla, Prentice-Hall
ISBN: 0-13-712965-3

Package that includes both the Text and Lab books:
ISBN: 0-13-704863-7

Check Blackboard for External Links and Course Documents to access additional resources

LEARNING ACTIVITIES

During this course, you are likely to experience the following learning activities:
Theory: Although the course is self-directed, lectures may be conducted to help explain course material. Students write tests, quizzes and lab reports

Practical: Experiments are conducted in a laboratory environment

Students complete related experiments at a workstation with professor guidance. Experiments for each unit must be completed and any accompanying lab reports must be submitted before a test is handed out

EVALUATION/EARNING CREDIT

The following will provide evidence of your learning achievements:	This activity validates the following Course Learning Requirements and/or Essential Employability Skills:

Quizzes 1 -- CLR 1 & 2 Chapters 1, 2 3% 2 -- CLR 3 ,4, 5 Chapters 7, 3, 4 3% 3 -- CLR 6 & 7 Chapter 5, 8 3% 4 -- CLR 8 Chapter 9, 10 3% 5 -- CLR 9,10 Chapters 11, 12 3% Total Unit Tests 15% Edit Delete	• Solve Boolean equations to find the minimum form - [CLR 5] • Recognize, analyse and design a number of shift registers - [CLR 10] • Analyse and design various counters - [CLR 9] • Design, test and program a PLD (Programmable Logic Device) to implement logic functions - [CLR 3] • Understand and apply the operations, codes and conversions between the various number systems - [CLR 2] • Describe the operation of digital logic gates - [CLR 4] • Understand Basic Digital Concepts - [CLR 1] • Define and create circuits using combinational logic - [CLR 6] • Understand and apply the different flip flops and their related devices - [CLR 8] • Describe the operation and application of binary and BCD counters, shift registers and other sequential logic circuits - [CLR 7] • Respond to written, spoken or visual messages in a manner that ensures effective communication. - [EES 2] • Apply a systematic approach to solve problems. - [EES 4] • Locate, select, organize and document information using appropriate technology and information systems. - [EES 6] • Analyze, evaluate and apply relevant information from a variety of sources. - [EES 7] • Manage the use of time and other resources to complete projects. - [EES 10] • Take responsibility for one's own actions, decisions and consequences. - [EES 11]
Unit Tests 1 -- CLR 1 & 2 Chapters 1,2 7.5% 2 -- CLR 3 ,4, 5 Chapters 7,3,4 7.5% 3 -- CLR 6 & 7 Chapter 5, 8 7.5% 4 -- CLR 8 Chapter 9,10 7.5% 5 -- CLR 9,10 Chapters 11,12 7.5% Total Unit Tests 37.5%	• Recognize, analyse and design a number of shift registers - [CLR 10] • Design, test and program a PLD (Programmable Logic Device) to implement logic functions - [CLR 3] • Understand Basic Digital Concepts - [CLR 1] • Understand and apply the operations, codes and conversions between the various number systems - [CLR 2] • Describe the operation of digital logic gates - [CLR 4] • Solve Boolean equations to find the minimum form - [CLR 5] • Analyse and design various counters - [CLR 9] • Describe the operation and application of binary and BCD counters, shift registers and other sequential logic circuits - [CLR 7] • Define and create circuits using combinational logic - [CLR 6] • Understand and apply the different flip flops and their related devices - [CLR 8] • Respond to written, spoken or visual messages in a manner that ensures effective communication. - [EES 2] • Apply a systematic approach to solve problems. - [EES 4] • Manage the use of time and other resources to complete projects. - [EES 10] • Take responsibility for one's own actions, decisions and consequences. - [EES 11]
Lab Tests	• Analyse and design various counters - [CLR 9]

1 -- CLR 1 & 2 Chapters 1,2 7.5% 2 -- CLR 3 ,4,5 Chapters 7,3,4 7.5% 3 -- CLR 6 & 7 Chapter 5, 8 7.5% 4 -- CLR 8 Chapter 9,10 7.5% 5 -- CLR 9,10 Chapters 11,12 7.5% Total Unit Tests 37.5% Edit Delete	- Design, test and program a PLD (Programmable Logic Device) to implement logic functions - [CLR 3] - Understand and apply the operations, codes and conversions between the various number systems - [CLR 2] - Describe the operation of digital logic gates - [CLR 4] - Recognize, analyse and design a number of shift registers - [CLR 10] - Understand Basic Digital Concepts - [CLR 1] - Define and create circuits using combinational logic - [CLR 6] - Understand and apply the different flip flops and their related devices - [CLR 8] - Describe the operation and application of binary and BCD counters, shift registers and other sequential logic circuits - [CLR 7] - Solve Boolean equations to find the minimum form - [CLR 5] - Respond to written, spoken or visual messages in a manner that ensures effective communication. - [EES 2] - Apply a systematic approach to solve problems. - [EES 4] - Analyze, evaluate and apply relevant information from a variety of sources. - [EES 7] - Manage the use of time and other resources to complete projects. - [EES 10] - Take responsibility for one's own actions, decisions and consequences. - [EES 11]
Lab Sign Off Sheets 10%	- Recognize, analyse and design a number of shift registers - [CLR 10] - Design, test and program a PLD (Programmable Logic Device) to implement logic functions - [CLR 3] - Understand Basic Digital Concepts - [CLR 1] - Understand and apply the operations, codes and conversions between the various number systems - [CLR 2] - Describe the operation of digital logic gates - [CLR 4] - Solve Boolean equations to find the minimum form - [CLR 5] - Analyse and design various counters - [CLR 9] - Describe the operation and application of binary and BCD counters, shift registers and other sequential logic circuits - [CLR 7] - Define and create circuits using combinational logic - [CLR 6] - Understand and apply the different flip flops and their related devices - [CLR 8] - Respond to written, spoken or visual messages in a manner that ensures effective communication. - [EES 2] - Apply a systematic approach to solve problems. - [EES 4] - Locate, select, organize and document information using appropriate technology and information systems. - [EES 6] - Analyze, evaluate and apply relevant information from a variety of sources. - [EES 7] - Manage the use of time and other resources to complete projects. - [EES 10] - Take responsibility for one's own actions, decisions and consequences. - [EES 11]

COLLEGE GRADING NUMERICAL EQUIVALENT TABLE

Final Grade	Mark Equivalent	Numeric Value	Final Grade	Mark Equivalent	Numeric Value
A+	90-100%	4.0	C+	67-69%	2.3
A	85-89%	3.8	C	63-66%	2.0
A-	80-84%	3.6	C-	60-62%	1.7
B+	77-79%	3.3	D+	57-59%	1.4
B	73-76%	3.0	D	53-56%	1.2
B-	70-72%	2.7	D-	50-52%	1.0
			F	0-49%	0
			FSP	0	0

OTHER COURSE INFORMATION

Students are required to respect the confidentiality of employer, client and/or patient information, interactions, and practices that occur either on Algonquin College premises, or at an affiliated clinical/field/co-op placement site. Concerns regarding clients, patients, and/or employer practices are to be brought to the attention of the program coordinator, or designated field/clinical/co-op placement supervisor so that they may be resolved collaboratively. Such concerns are not to be raised publically either verbally, in writing, or in electronic forums. These matters are to be addressed through established program communication pathways.

PRIOR LEARNING ASSESSMENT AND RECOGNITION

Students who wish to apply for prior learning assessment and recognition (PLAR) need to demonstrate competency at a post-secondary level in all of the course learning requirements outlined above. Evidence of learning achievement for PLAR candidates includes:

- Portfolio
- Challenge Exam
- Performance Test
- Project/Assignment

RELATED INFORMATION

The following information is course-specific:

Required Equipment:

Safety Glasses
Closed-toed shoes
Electronics toolkit consisting of cutters, wire strippers, needlenose pliers, protoboard, small electronic screwdriver kit, 2 oscilloscope leads, 2 BNC to alligator leads and 3 sets of meter leads.

Refer to your CSI under Course Information on Blackboard for the updated Lab and Testing Policy.

The following information is school/department-specific:

GENERAL CLAUSES - School of Advanced Technology

Harassment/Discrimination/Violence will not be tolerated. Any form of harassment (sexual, racial, gender or disability-related), discrimination (direct or indirect), or violence, whether towards a professor or amongst students, will not be tolerated on the college premises. Action taken will start with a formal warning and proceed to the full disciplinary actions as outlined in Algonquin College Policy - HR22.

Harassment means one or a series of vexatious comment(s) or conduct related to one or more of the prohibited grounds that is known or ought reasonably to be known to be unwelcome/ unwanted, offensive, intimidating, derogatory or hostile.

This may include, but is not limited to: gestures, remarks, jokes, taunting, innuendo, display of offensive materials, offensive graffiti, threats, verbal or physical assault, academic penalties, stalking, slurs, shunning or exclusion related to the prohibited grounds.

For further information, a copy of the official policy statement can be obtained from the Student Association.

The Use of Electronic Devices , with the sound turned on, during classes is strictly prohibited. In particular, cell phones are not to be used to communicate during a class. The use of any electronic devices during exams and mid-term tests, other than those sanctioned by the faculty in charge of the examination, is strictly prohibited.

Anyone caught using a prohibited device will be considered to have plagiarized, and will be treated as such in accordance with College Plagiarism Policy. For further details on this directive, consult the Algonquin College Policy AA32 on the use of Electronic Devices in Class and Exams.

The School of Advanced Technology' s Standard Operating Procedure on Plagiarism and Academic Honesty defines plagiarism as an attempt to use or pass off as one's own idea or product, work of another without giving credit. Plagiarism has occurred in instances where a student either directly copies another person's work without acknowledgement; or, closely paraphrases the equivalent of a short paragraph or more without acknowledgement; or, borrows, without acknowledgement, any ideas in a clear and recognizable form in such a way as to present them as one's own thought, where such ideas, if they were the student's own would contribute to the merit of his or her own work.

Plagiarism is one of the most serious academic offenses a student can commit. Anyone found guilty will, on the first offense, be given a written warning and an F on the plagiarized work. If the student commits a second offense, an F will be given for the course along with a written warning. A third offense will result in suspension from the program and/or the college.

For further details on this directive, consult the Algonquin College Policy - AA20 and the School of Advanced Technology' s Standard Operating Procedure on Plagiarism and Academic Dishonesty.

Respect for Confidentiality

Students are required to respect the confidentiality of employer, client and/or patient information, interactions, and practices that occur either on AlgonquinCollege premises, or at an affiliated clinical/field/co-op placement site. Concerns regarding clients, patients, and/or employer practices are to be brought to the attention of the program coordinator, or designated field/clinical/co-op placement supervisor so that they may be resolved collaboratively. Such concerns are not to be raised publically either verbally, in writing, or in electronic forums. These matters are to be addressed through established program communication pathways

Disruptive Behaviour is any conduct, or threatened conduct, that is disruptive to the learning process or that interferes with the well-being of other members of the College community. It will not be tolerated.

Members of the College community, both students and staff, have the right to learn and work in a secure and productive environment. The College will make very effort to protect that right.

Incidents of disruptive behaviour must be reported in writing to the departmental Chair as quickly as possible. The Chair will hold hearings to review available information and determine any sanctions that will be imposed. Disciplinary hearings can result in penalties ranging from a written warning to expulsion.

For further details consult the Algonquin College Policy - SA07.

June 15, 2012

The following information is College-wide:

Email
Algonquin College provides all full-time students with an e-mail account. This is the address that will be used when the College, your professors, or your fellow students communicate important information about your program or course events. It is your responsibility to ensure that you know how to send and receive e-mail using your Algonquin account and to check it regularly.

Centre for Students with Disabilities (CSD)
If you are a student with a disability, it is strongly recommended that you identify your needs to the professor and the Centre for Students with Disabilities (CSD) by the end of the first month of the semester in order that any necessary support services can be arranged for you.

Academic Integrity* & Plagiarism*
Adherence to acceptable standards of academic honesty is an important aspect of the learning process at Algonquin College. Academic work submitted by a student is evaluated on the assumption that the work presented by the student is his or her own, unless designated otherwise. For further details consult Algonquin College Policies AA18 **http://www2.algonquincollege.com/directives/files/2012/04/AA18.pdf** and AA20 **http://www2.algonquincollege.com/directives/files/2011/08/AA20.pdf**

Student Course Feedback*
It is Algonquin College's policy to give students the opportunity to complete a course assessment survey in each course that they take which solicits their views regarding the curriculum, the professor and the facilities. For further details consult Algonquin College Policy AA25 **http://www2.algonquincollege.com/directives/files/2011/10/AA25.pdf**

Use of Electronic Devices in Class*
With the proliferation of small, personal electronic devices used for communications and data storage, Algonquin College believes there is a need to address their use during classes and examinations. During classes, the use of such devices is disruptive and disrespectful to others. During examinations, the use of such devices may facilitate cheating. For further details consult Algonquin College Policy AA32 **http://www2.algonquincollege.com/directives/files/2011/11/AA32.pdf**

Transfer of Credit
Students, it is your responsibility to retain course outlines for possible future use to support applications for transfer of credit to other educational institutions.

***** College policies (previously called directives) are under review and redesign. The term *directives* is being retired. As such, the policy

classification nomenclature is in transition. Students, it is your responsibility to refer to the Algonquin College Directives/Policies website for the most current information available at**:(http://www2.algonquincollege.com/directives/)**