PGT104 - Digital Electronics

This course is *Digital Electronics*, offered by the Department of Electronics Engineering Technology.

The textbook for this course is Floyd's Digital Fundamentals (11th Edition at the moment).

Try my1digitaljs - a Basic Digital Electronics Simulator (notice, NOT logic simulator :p) that I have developed for PGT104. Based on SimCirJS, the source is available here. Some video guides are available on Youtube

Please note that this is a continuously updated site. Check the timestamps/dates (if any) to make sure that the information is applicable to current course implementation. Some information are from the previous ones.

Announcements

[20190130] Welcome to PGT104 Academic Session 2018/19 S2!

[20190226] Tentative date for Mid-Term is 21/03/2019 (THU)!

[20190307] Mid-Term Exam set on 19/03/2019 (TUE) @9.00pm

Lecture Slides

Applicable for Academic Session 2018/2019 Semester 2

- Lecture Part 0 - Course Introduction
- Lecture Part 1 - Introduction to Number Systems
- Lecture Part 2 - Logic Gates
- Lecture Part 3 - Boolean Algebra
- Lecture Part 4 - Combinational Logic Circuits
- Lecture Part 5 - Latches, Flip-flop and Timers
- Lecture Part 6 - Sequential Logic Circuits

***Note**: Textbook coverage is as follows...*

Topic	Chapter	Sections
1	2	(2.1)-(2.10)
2	3	(3.1)-(3.6)
3	4	(4.1)-(4.8)
4	6	(6.1)-(6.9)
5	7	(7.1)-(7.6)
6	8-9	(8.1)-(8.4), (9.2)-(9.3)

Lab Notes

- Lab Work 1 - Basic Equipment/Components (Part 1,Part 2)
- Lab Work 2 - Combinational Logic Circuits (Part 1,Part 2,Part 3)
- Lab Work 3 - Sequential Logic Circuits (Part 1, Part 2, Part 3)
- Lab Work 4 - (Free sessions) Shift registers and counters (theory to practical)

Assignments

- Assignment 1
  - Please attach this page (with your name and student ID) in front of your answer sheets.
  - **Due: 14/03/2019 (THU-W6-Lecture Session)**.
- Assignment 2
  - Please attach this page (with your name and student ID) in front of your answer sheets.
  - **Due: 09/05/2019 (THU-W13-MY_ROOM@[S4-L1-70]-12PM)**.

Course Synopsis

Note: Written by the course coordinator when first offered

Introduction and discussion of fundamental of digital circuit design and analysis. The lecture and tutorial exercise covers the following topics: Boolean Algebra, Numbering System, Basic Logic Gates, Combinational Circuit Design, Timing Diagram, Bi-Stable Memory Device and Sequential Circuit Design.

Course Outcome

Note: These have been slightly re-written from the original/previous session

- CO1: Ability to describe numbering systems and boolean algebra
- CO2: Ability to analyze Boolean expressions and logic circuits for a simple digital system
- CO3: Ability to design combinational or sequential logic circuits for a simple digital system

Course Assessment

	Examinations		**Course Work**	
Total Contribution	60%		40%	
Assessment	Mid-Term	Final Exam	Assignments	Lab Assessments
Contribution	10%	50%	10%	30%

Course Syllabus

Week	Lecture	Laboratory	Notes

Week 01	• Course Introduction (Lecture 00)
	  ◦ introduction to digital electronics
	• Introduction to Numbering Systems (Lecture 01)
	  ◦ decimal numbers, binary numbers
	  ◦ conversions, binary arithmetic
	  ◦ value and representation
	  ◦ hexadecimal and octal numbers
	  ◦ binary-coded decimal
		Lab Work 1	Textbook: Chapter 2

Week 02	• Logic Gates (Lecture 02)
	  ◦ Boolean Logic, Inverter
	  ◦ (N)AND, (N)OR, X(N)OR gates
		Lab Work 1 (cont.)	Textbook: Chapter 3

Week 03	• Boolean Algebra (Lecture 03)
	  ◦ Boolean operations and expressions
	  ◦ DeMorgan's Theorems
	  ◦ logic simplification
		Lab Work 2	Textbook: Chapter 4
			Assignment 1 Queue

Week 04	• Boolean Algebra (cont.) (Lecture 03)
	  ◦ standard forms: SOP, POS
	  ◦ truth table and Karnaugh Map
		Lab Work 2 (cont.)	Textbook: Chapter 4

Week 05	• Boolean Algebra (cont.) (Lecture 03) ◦ practical problems & solutions	Lab Work 2 (cont.)	Textbook: Chapter 4 **Assignment 1 Due (5%)**

Week 06	• Combinational Logic Circuits (Lecture 04)
	  ◦ half & full adders
	  ◦ carry circuits
	  ◦ comparators
		Lab Work 2 (cont.)	Textbook: Chapter 6
			Lab Assessment 1 (10%)

Week	Lecture	Laboratory	Notes
Week 07	• Combinational Logic Circuits (cont.) (Lecture 04) ◦ decoders, encoders ◦ multiplexer, demultiplexer	Lab Work 2 (cont.)	Textbook: Chapter 6 **Mid-term Examination (10%)**
Week 08	• Combinational Logic Circuits (cont.) (Lecture 04) ◦ applications in digital systems	Lab Work 2 (cont.)	Textbook: Chapter 6
Week 09	• Latches, Flip-flops, and Timers (Lecture 05) ◦ latches & flip-flops	Lab Work 3	Textbook: Chapter 7 **Assignment 2 Queue**
Week 10	• Latches, Flip-flops, and Timers (cont.) (Lecture 05) ◦ one-shots and oscillators	Lab Work 3 (cont.)	Textbook: Chapter 7 **Lab Assessment 2 (10%)**
Week 11	• Latches, Flip-flops, and Timers (cont.) (Lecture 05) ◦ applications in digital systems	Lab Work 3 (cont.)	Textbook: Chapter 7 **Assignment 2 Due (5%)**
Week 12	• Sequential Logic Circuits (Lecture 06) ◦ shift registers (load, shift left, shift right)	Lab Work 3 (cont.)	Textbook: Chapter 8-9
Week 13	• Sequential Logic Circuits (cont.) (Lecture 06) ◦ counters (asynchronous, synchronous)	Lab Work 3 (cont.)	Textbook: Chapter 8-9
Week 14	• Sequential Logic Circuits (cont.) (Lecture 06) ◦ applications in digital systems	Lab Work 3 (cont.)	Textbook: Chapter 8-9 **Lab Assessment 3 (10%)**

Once Upon a Time in PGT104

20170526 *Project Demonstration: A Car-Wash System using a state-machine built with discrete logic gates*



Short video clip (*sorry, no audio*)

pgt104_lab_project_ry44_grade_a.mp4

Digital Electronic Lab Kit

pgt104_labkit.txt

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Basic Gates / IC:
- 2 x 7400 - Quad 2-input NAND
- 1 x 7404 - Hex INVERTER
- 1 x 7408 - Quad 2-input AND
- 1 x 7402 - Quad 2-input NOR
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- 1 x 7432 - Quad 2-input OR
- 1 x 7486 - Quad 2-input XOR
- 2 x 7474 - Dual D Flip-flop (async P/C)
- 1 x 7476 - Dual JK Flip-flop (async P/C)
- 1 x 555 - Timer

Basic Components:
- 4 x LED (Red/Green)
- 4 x Push/Reset Button
- 1 x 4-Way DIP Switch
- 12 x 1k Resistor
- 1 x 7-segment
- 8 x 220ohm Resistor
- 2 x 100k Resistor
- 2 x 10k Resistor
- 1 x 10uF Capacitor
- 1 x 1uF Capacitor
- 1 x 10nF Capacitor

Prototyping:
- Breadboard
- Jumper wires (M-M)
- @ 4 long wires for power
- @ 8 medium length for inter-IC
- @ 38 short length for direct wiring
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Food for Thought

A more practical implementation of Digital Electronic Courses:

- Digital 1
  - base-n numbering systems
  - basic logic (truth table, boolean equation, boolean algebra, POS/SOP form)
  - combinational logic (basic gates)
  - combinational logic implementation (e.g. adder) ← just pick one example
  - sequential logic (basic flip-flop)
- Digital 2 :
  - combinational logic circuits (mux, decoder, encoder)
  - practical application: e.g. instruction decoder, address decoding, etc.
  - sequential logic circuits (registers, counters)
  - practical application: e.g. program counter
  - state machines

Note: *If Digital 1 is seen as too light, the combinational logic circuits topic from 2 can be shifted into 1… then, some basic Computer Architecture stuffs can be put into 2.*

Maybe something like this…

Digital Electronics 1			
Week	**Lecture**	**Laboratory**	**Notes**

Week 01 - 03	• Introduction to Digital Electronics
	• Numbering Systems
	  ◦ decimal numbers, binary numbers
	  ◦ conversions
	  ◦ basic binary arithmetic
	  ◦ hexadecimal and octal numbers
	  ◦ binary-coded decimal
	• Logic Gates
	  ◦ Boolean Logic, Inverter
	  ◦ (N)AND, (N)OR, X(N)OR gates
	• Numbering Systems (cont.)
	  ◦ unsigned and signed binary
	  ◦ signed binary arithmetic
			*Comment1: Need to cover topic on **Logic Gates** as soon as possible in order to start with lab sessions.*
			Comment2: Previous experience show students need more time on topics involving signed binaries.

Week 04 - 07	• Boolean Algebra
	  ◦ Boolean operations and expressions
	  ◦ DeMorgan's Theorems
	  ◦ Logic simplification/reduction
	  ◦ standard forms: SOP, POS
	  ◦ truth table and Karnaugh Map		

Week 08 - 11	• Combinational Logic Circuits
	  ◦ 1-bit half & full adder
	  ◦ 4-bit adders (ripple carry)
	  ◦ carry circuit (carry look ahead)		

Digital Electronics 1			
Week	**Lecture**	**Laboratory**	**Notes**

Week 12 - 14	• Latches, Flip-flops, and Timers
	  ◦ latches
	  ◦ timing diagrams
	  ◦ flip-flops (JK-FF, D-FF, T-FF)
	  ◦ basic 555 timer		

Digital Electronics 2			
Week	**Lecture**	**Laboratory**	**Notes**

Week 01 - 02	• Refresh Basic Digital Electronics
	  ◦ combinational & sequential
	  ◦ boolean algebra, timing diagrams
	• Combinational Logic Circuits
	  ◦ adder, subtractor, binary comparator		

Week 03 - 05	• Combinational Logic Circuits
	  ◦ Decoders, encoders
	  ◦ Multiplexers, demultiplexers		

Week 06 - 07	• Refresh Sequential Logic Elements ◦ latches/flip-flops • Shift Registers (left/right/load)		

Week 08 - 09	• Counters
	  ◦ Basic binary counter (up/down)
	  ◦ Gray Counter		

Week 10 - 12	• Finite State Machine
	  ◦ Mealy/Moore Machine
	  ◦ State diagrams
	  ◦ State encoding
	  ◦ Next-state logic		

Digital Electronics 1			
Week	**Lecture**	**Laboratory**	**Notes**
Week 13 - 14	• Simple Digital Systems (Case studies) ◦ digital control system (e.g. train crossing gate control)		

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Last update: **2026/02/08 03:46**