SENG 11232 · Engineering Foundation
STUDENT PRE-LECTURE NOTES · LECTURE 05

# Digital Logic & Boolean Algebra

Module 2 — Systems & Digital Foundations

**HOW TO USE** Read these notes BEFORE the lecture. Highlight terms you don't recognise. Bring your questions to class. Use the blank spaces for your own notes.

## Learning Objectives

By the end of this lecture, you should be able to:

- 1. Apply Boolean algebra laws and De Morgan's theorems
- 2. Construct and analyse truth tables for up to 3 variables
- 3. Minimise Boolean expressions using Karnaugh maps
- 4. Explain the operation of D, JK and T flip-flops

## Boolean Algebra

### Key Laws

- Identity: A·1=A | A+0=A
- Null: A·0=0 | A+1=1
- Complement: A·Ā=0 | A+Ā=1
- De Morgan's: $(A \cdot B)' = \bar{A} + \bar{B}$ | $(A + B)' = \bar{A} \cdot \bar{B}$

**KEY** NAND and NOR are universal gates — any Boolean function can be implemented using only NAND gates (or only NOR gates).

### Karnaugh Map Minimisation

- Group 1s into groups of powers of 2 (1,2,4,8,16)
- Groups can wrap around edges (torus topology)
- Each group of 2^n cells eliminates n variables
- Write product term for each group; OR all terms together

*Your notes:*

## Sequential Logic & ADC

### Flip-Flops

- D flip-flop: Q copies D on the rising clock edge — most used, no forbidden state
- JK flip-flop: J=K=1 toggles output — useful for counters
- T flip-flop: toggles on each clock when T=1 — basis of binary counters

### ADC & Nyquist Theorem

- ADC resolution: n bits gives 2^n discrete levels; V_LSB = V_REF / 2^n
- Nyquist theorem: sample rate f_s must satisfy f_s ≥ 2 × f_max
- Aliasing: if f_s < 2×f_max, high-frequency signals appear as false lower frequencies

| NOTE | Audio CD: 44.1 kHz sample rate supports up to 22.05 kHz. Human hearing tops at ~20 kHz. The margin allows practical anti-aliasing filter design. |
|---|---|

*Your notes:*

## Key Terms for This Lecture

| Term | Your Definition (fill in during/after lecture) |
|---|---|
| Boolean Algebra | |
| Logic Gate | |
| Truth Table | |
| K-map (Karnaugh Map) | |
| SOP (Sum of Products) | |
| Flip-Flop | |
| D Flip-Flop | |
| Clock Edge | |
| ADC | |
| Nyquist Theorem | |
| Aliasing | |

## Self-Check Questions

Answer these after the lecture to test your understanding:

- Q1. Simplify: F = A·B + A·$\overline{B}$ + $\overline{A}$·B using Boolean algebra.

*Answer:* _____

- Q2. Draw the truth table for F = (A XOR B) AND C.

*Answer:* _____

- Q3. What does a D flip-flop do on a rising clock edge?

*Answer:* _____

- Q4. An ADC has 10-bit resolution and a 5V reference. What is the LSB voltage?

*Answer:* _____

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