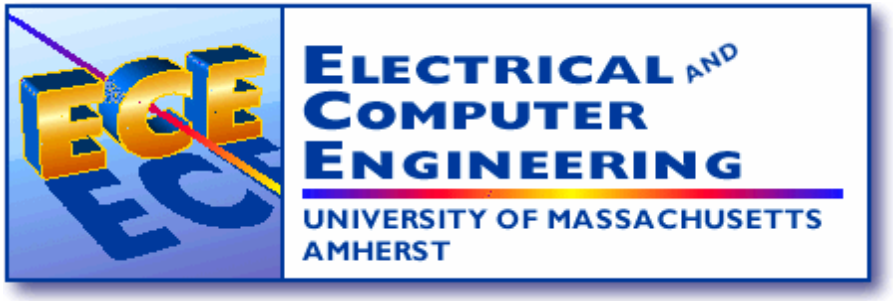
ENGIN 112

Intro to Electrical and Computer Engineering

Lecture 12

Circuit Analysis Procedure

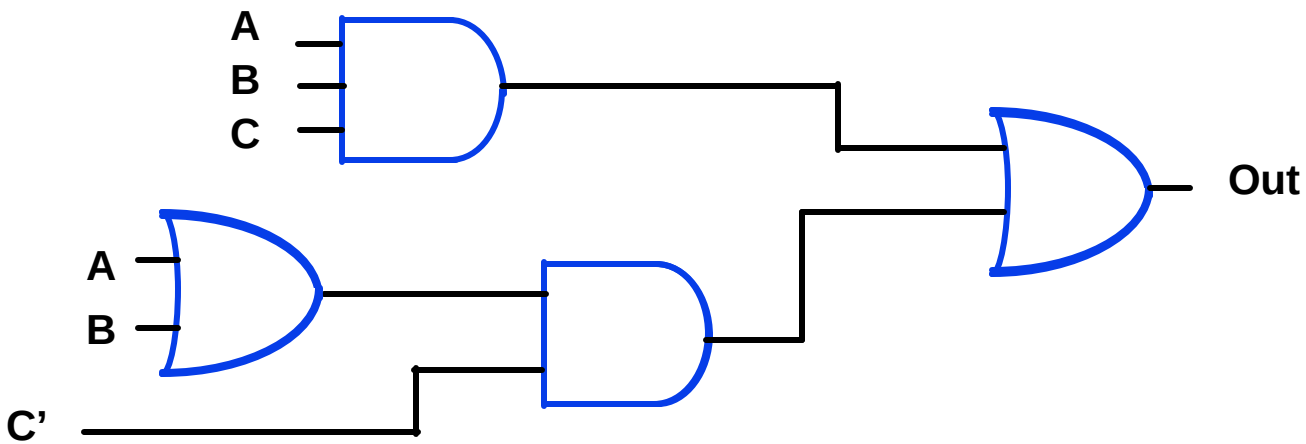


Overview

- **Important concept – analyze digital circuits**
  - **Given a circuit**
    - **Create a truth table**
    - **Create a minimized circuit**
- **Approaches**
  - **Boolean expression approach**
  - **Truth table approach**
- **Leads to minimized hardware**
- **Provides insights on how to design hardware**
  - **Tie in with K-maps (next time)**

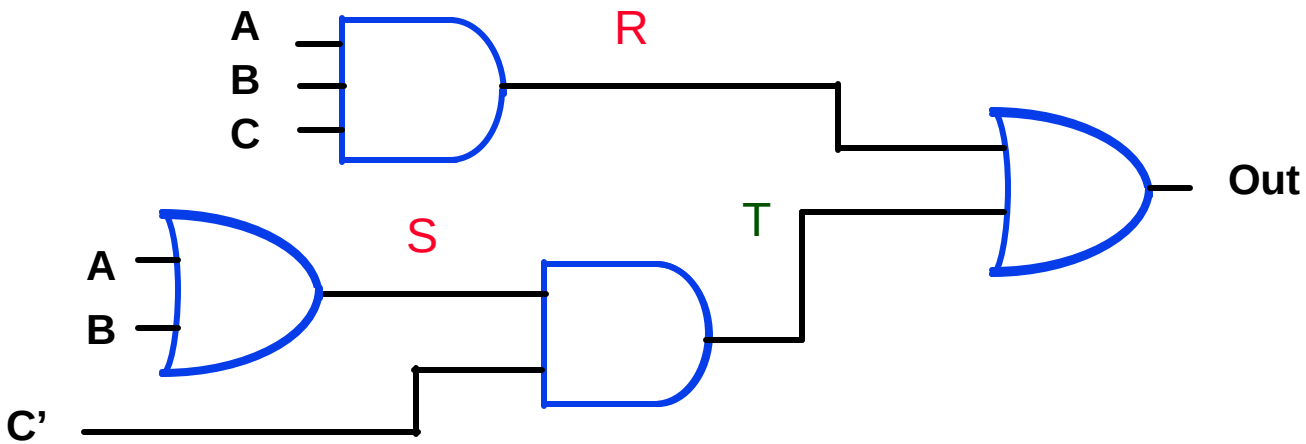
The Problem

- How can we convert from a circuit drawing to an equation or truth table?
- Two approaches
  - Create intermediate equations
  - Create intermediate truth tables



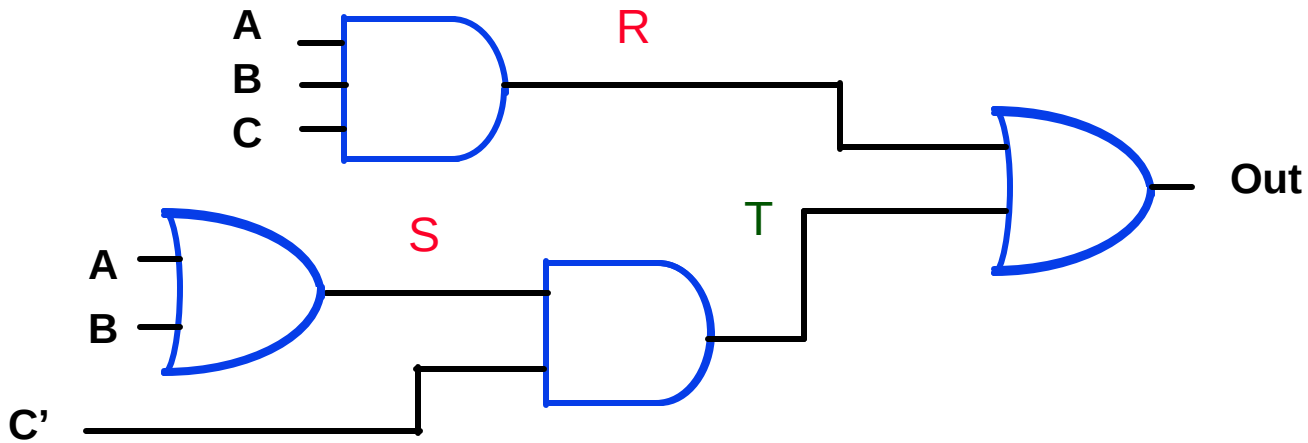
Label Gate Outputs

1. **Label all gate outputs that are a function of input variables.**
2. **Label gates that are a function of input variables and previously labeled gates.**
3. **Repeat process until all outputs are labelled.**



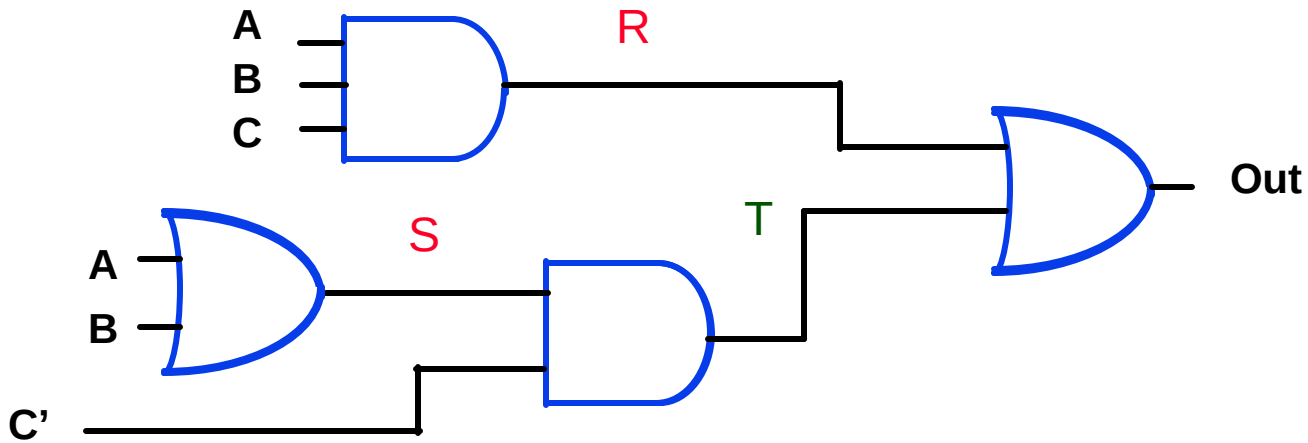
Approach 1: Create Intermediate Equations

- **Step 1: Create an equation for each gate output based on its input.**
  - **R = ABC**
  - **S = A + B**
  - **T = C'S**
  - **Out = R + T**



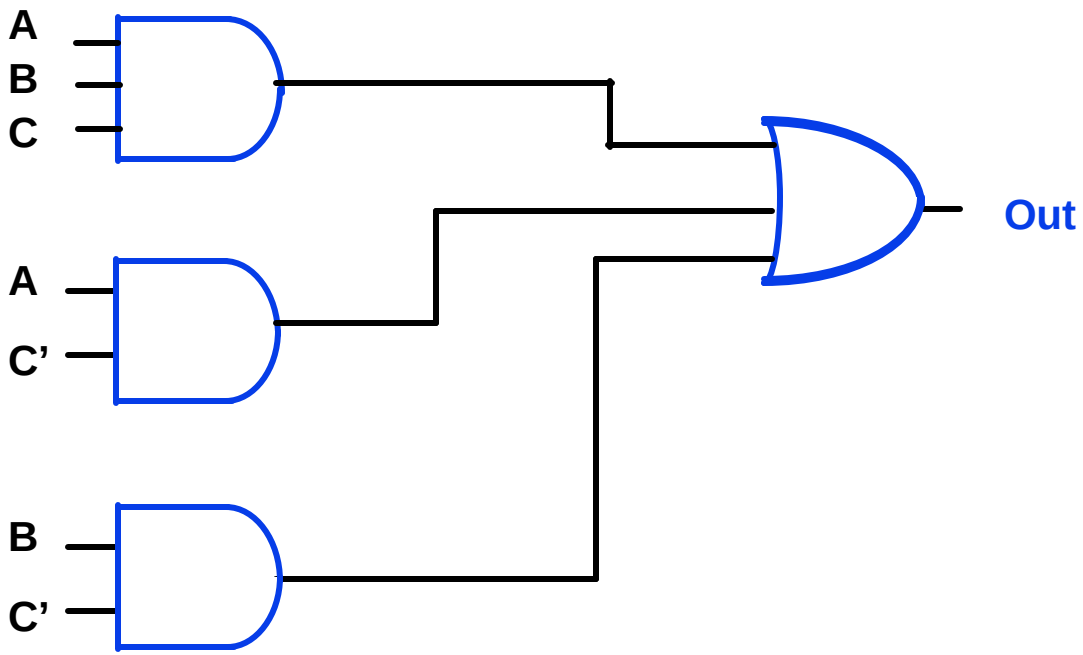
Approach 1: Substitute in subexpressions

- **Step 2: Form a relationship based on input variables (A, B, C)**
  - **R = ABC**
  - **S = A + B**
  - **T = C'S = C'(A + B)**
  - **Out = R+T = ABC + C'(A+B)**



Approach 1: Substitute in subexpressions

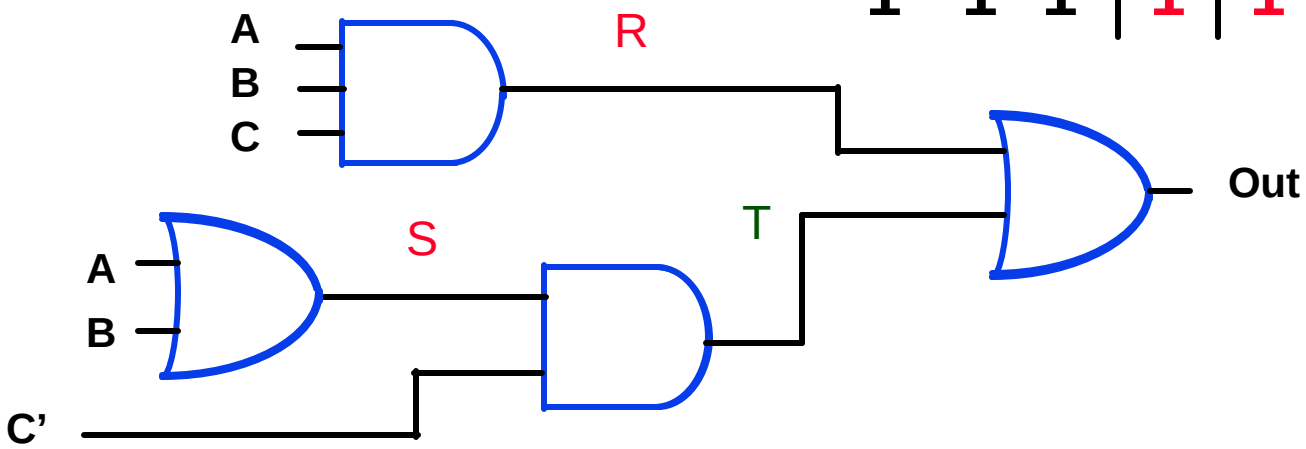
- **Step 3: Expand equation to SOP final result**
  - **Out = ABC + C'(A+B) = ABC + AC' + BC'**



Approach 2: Truth Table

- **Step 1: Determine outputs for functions of input variables.**

A	B	C	R	S
0	0	0	0	0
0	0	1	0	0
0	1	0	0	1
0	1	1	0	1
1	0	0	0	1
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

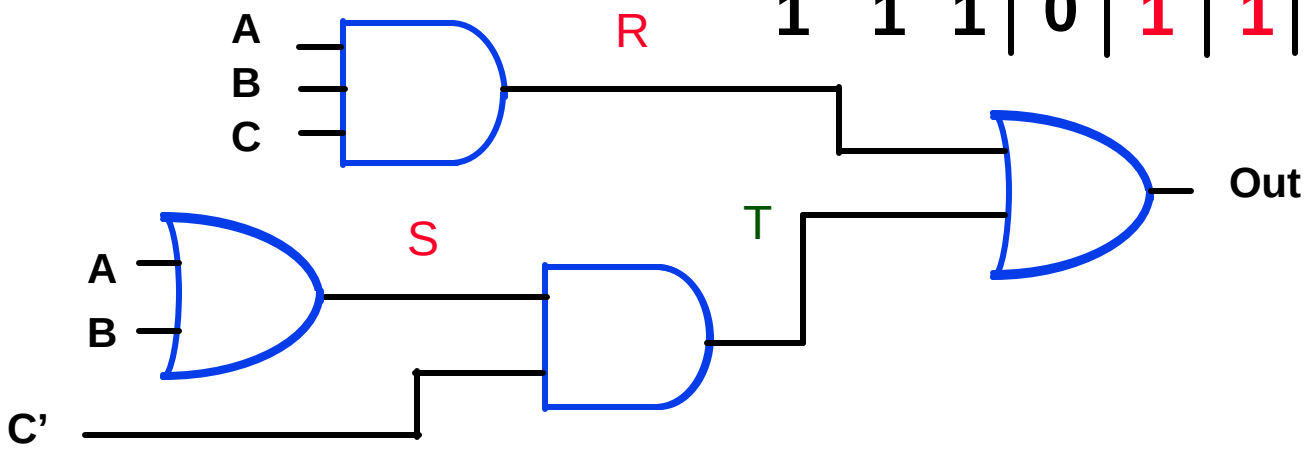


Approach 2: Truth Table

- **Step 2: Determine outputs for functions of intermediate variables.**

$T = S * C'$

A	B	C	C'	R	S	T
0	0	0	1	0	0	0
0	0	1	0	0	0	0
0	1	0	1	0	1	1
0	1	1	0	0	1	0
1	0	0	1	0	1	1
1	0	1	0	0	1	0
1	1	0	1	0	1	1
1	1	1	0	1	1	0

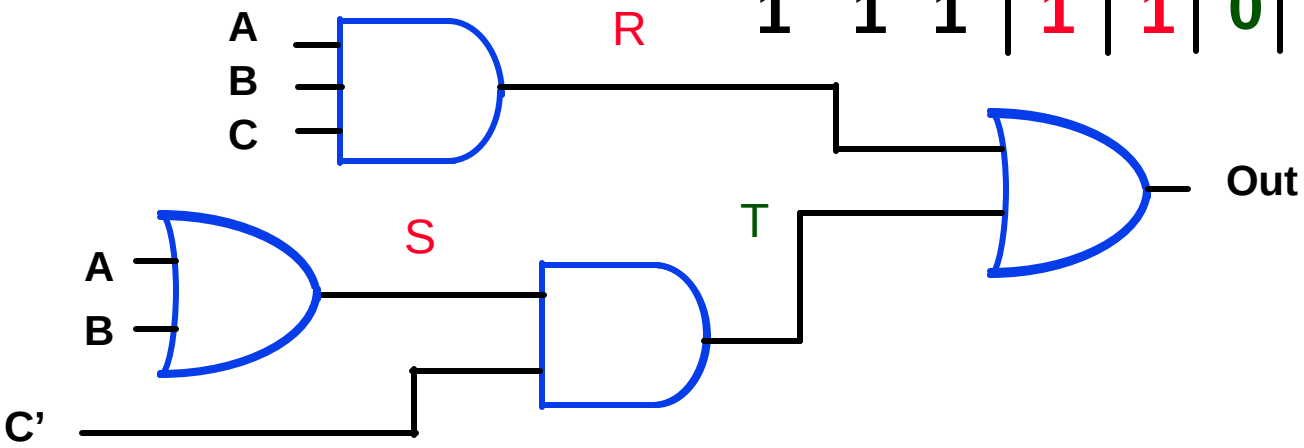


Approach 2: Truth Table

- **Step 3: Determine outputs for function.**

R + T = Out

A	B	C	R	S	T	Out
0	0	0	0	0	0	0
0	0	1	0	0	0	0
0	1	0	0	1	1	1
0	1	1	0	1	0	0
1	0	0	0	1	1	1
1	0	1	0	1	0	0
1	1	0	0	1	1	1
1	1	1	1	1	0	1



More Difficult Example

- **Step 3: Note labels on interior nodes**

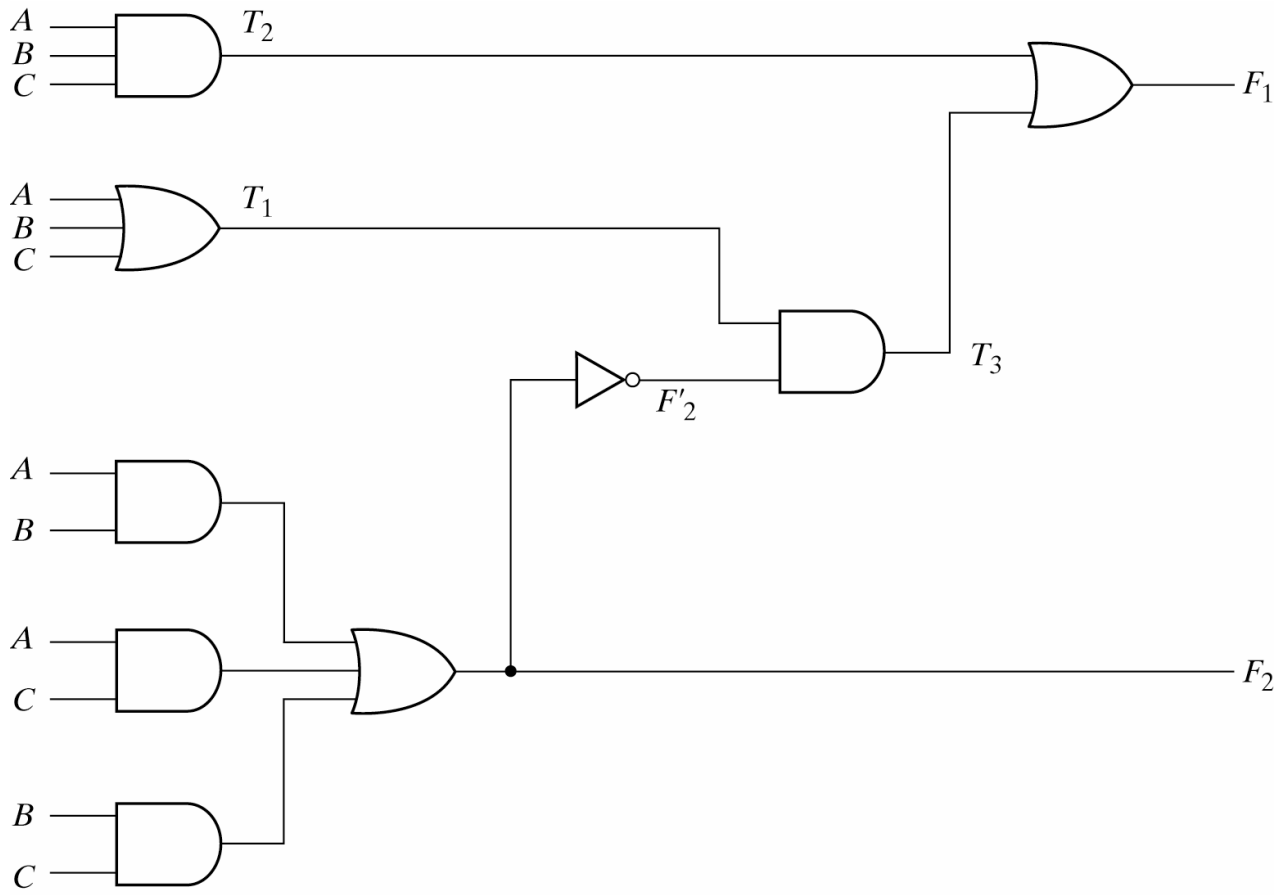


Fig. 4-2 Logic Diagram for Analysis Example

More Difficult Example: Truth Table

- Remember to determine intermediate variables starting from the inputs.
- When all inputs determined for a gate, determine output.
- The truth table can be reduced using K-maps.

A	B	C	F_2	F'_2	T_1	T_2	T_3	F_1
0	0	0	0	1	0	0	0	0
0	0	1	0	1	1	0	1	1
0	1	0	0	1	1	0	1	1
0	1	1	1	0	1	0	0	0
1	0	0	0	1	1	0	1	1
1	0	1	1	0	1	0	0	0
1	1	0	1	0	1	0	0	0
1	1	1	1	0	1	1	0	1

Summary

- Important to be able to convert circuits into truth table and equation form
  - WHY? ---- leads to minimized sum of product representation
- Two approaches illustrated
  - Approach 1: Create an equation with circuit output dependent on circuit inputs
  - Approach 2: Create a truth table which shows relationship between circuit inputs and circuit outputs
- Both results can then be minimized using K-maps.
- Next time: develop a minimized SOP representation from a high level description