Combinational Logic Design Process

1. Understand the Problem
   what is the circuit supposed to do?
   write down inputs (data, control) and outputs
   draw block diagram or other picture

2. Formulate the Problem in terms of a truth table or other suitable
   design representation
   truth table, Boolean Algebra, Verilog, etc.

3. Choose Implementation Target

4. Follow Implementation Procedure
   K-maps, Boolean algebra, Quartus synthesis

Process Line Control Example

Statement of the Problem
   Rods of varying length (+/-10%) travel on conveyor belt
   Mechanical arm pushes rods within spec (+/-5%) to one side
   Second arm pushes rods too long to other side
   Rods too short stay on belt
   3 light barriers (light source + photocell) as sensors
   Design combinational logic to activate the arms

Understanding the Problem
   Inputs are three sensors, outputs are two arm control signals
   Assume sensor reads "1" when tripped, "0" otherwise
   Call sensors A, B, C
   Draw a picture!
Where to place the light sensors A, B, and C to distinguish among the three cases?

Assume that A detects the leading edge of the rod on the conveyor.
Process Line Control Example (cont.)

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<th>A</th>
<th>B</th>
<th>C</th>
<th>Meaning</th>
<th>Accept</th>
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Logical Function Unit

Create a unit that can compute the AND, OR, or XOR of two inputs A and B, based upon control lines C0 and C1.

Similar to the main computation unit in a Microprocessor
Logical Function Unit (cont.)

- Implementation:

Debugging Complex Circuits

- Complex circuits require careful debugging
  - Rip up and retry?
- Ex. Debug a 9-input odd parity circuit
  - True if an odd number of inputs are true

```
A
B 3-Parity Out
C
```

```
A
B 3-Parity Out
C
```

```
A
B 3-Parity Out
C
```

```
A
B 3-Parity Out
C
```
Debugging Complex Circuits (cont.)

A
B 3-Parity Out
C

Debugging Approach

- Test all behaviors.
  - All combinations of inputs for small circuits, subcircuits.

- Identify any incorrect behaviors.

- Examine inputs and outputs to find earliest place where value is wrong.
  - Typically, trace backwards from bad outputs, forward from inputs.
  - Look at values at intermediate points in circuit.

- DO NOT RIP UP, DEBUG!