Functional Blocks

- Fundamental circuits that are the base building blocks of most larger digital circuits
- They are reusable.
- Examples of functional logic circuits
  - Decoders: selecting things like a bank of memory and then the address within the bank. This is also the function needed to 'decode' the instruction to determine the operation to perform.
  - Encoders: are used in various components such as keyboards
  - Multiplexers: Selectors for routing data to the processor, memory, I/O

Steps for logical design

- Specification
- Formulation
- Optimization
- Technology mapping
- Verification

Specification

- Write a specification for the circuits
  - What are the inputs: how many bits in a given input ?
  - What are the outputs: how many bits in output?
  - The functional operation that takes place in the chip, i.e., for given inputs what will appear on the outputs.

Formulation

- Convert the specifications into a variety forms for optimal implementation.
  - Possible forms
    - Truth Tables
    - Expressions
    - K-maps

Example: BCD to Excess 3 converter

- BCD and Excess-3 are both code for the decimal digits 0-9
- Truth Table

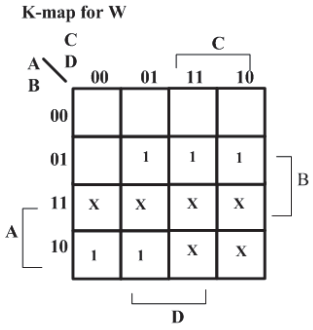
Decimal Digit	Input BCD	Output Excess-3
0	0 0 0 0	0 0 1 1
1	0 0 0 1	0 1 0 0
2	0 0 1 0	0 1 0 1
3	0 0 1 1	0 1 1 0
4	0 1 0 0	0 1 1 1
5	0 1 0 1	1 0 0 0
6	0 1 1 0	1 0 0 1
7	0 1 1 1	1 0 1 0
8	1 0 0 0	1 0 1 1
9	1 0 0 1	1 1 0 0

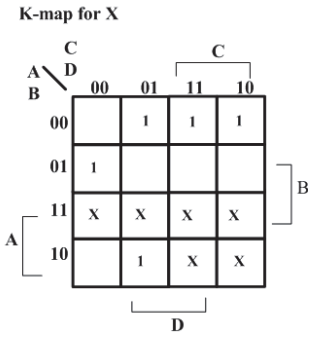
Specification

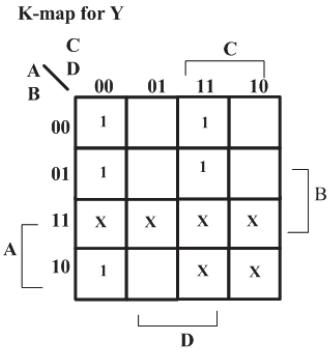
- Inputs: a BCD input, A,B,C,D with A as the most significant bit and D as the least significant bit.
- Outputs: an Excess-3 output W,X,Y,Z that corresponds to the BCD input.
- Internal operation – circuit to do the conversion in combinational logic.

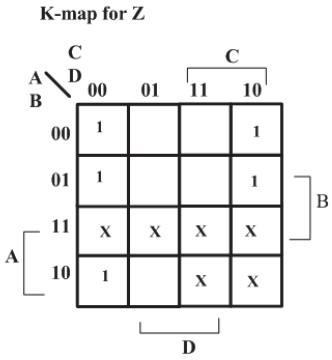
Formulation

- Lay out K-maps for each output, W X Y Z



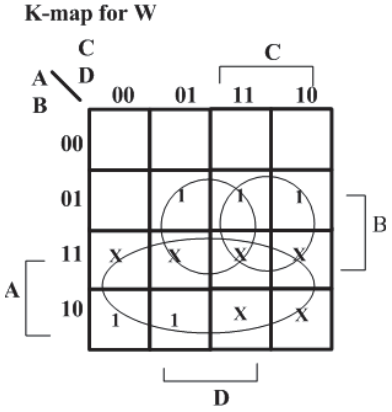




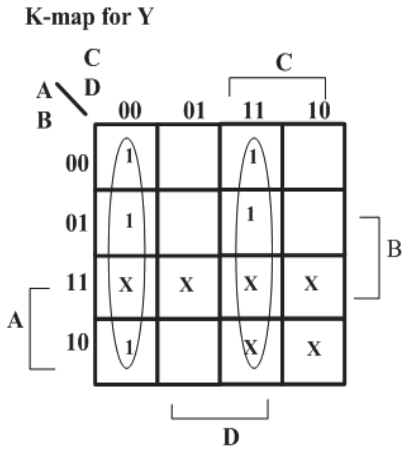


Optimization

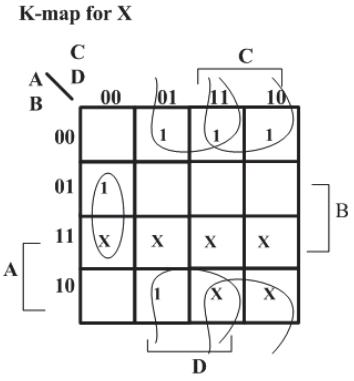
- W = A + BC + BD



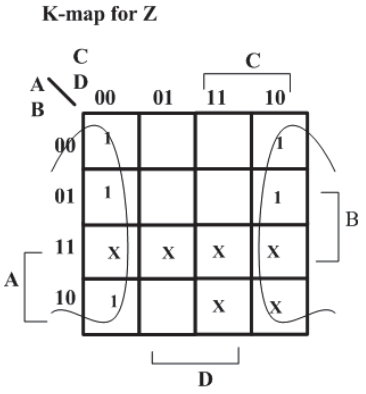
- Y = CD + C'D'



- X = BC'D'+B'C+B'D



- Z = D'



circuit implementation

- Equations
  - W = A + BC + BD = A + B(C+D)
  - X = B'C + B'D + BC'D' = B'(C+D) + BC'D'
  - Y = CD + C'D'
  - Z = D'
- Factoring out (C+D), call it T
- Then T' = (C+D)' = C'D'
  - W = A + BT
  - X = B'T + BT'
  - Y = CD + T'
  - Z = D'