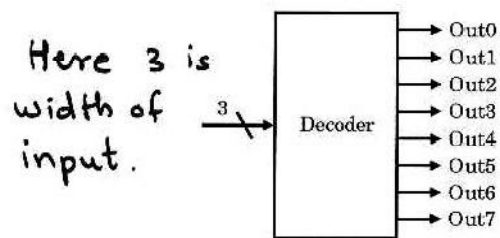


Lecture 17

Digital Logic: Decoders, Encoders, Multiplexors, Demultiplexors

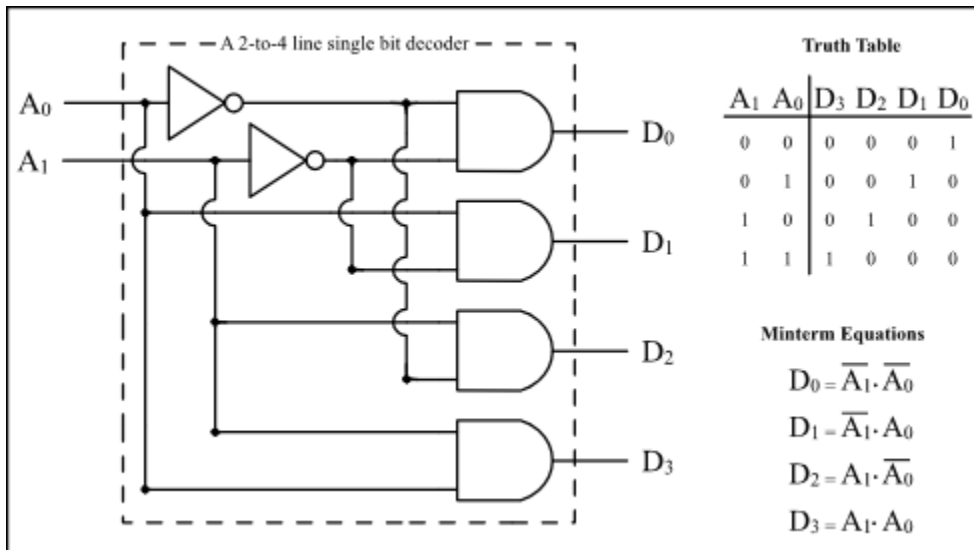
Decoder

- Logical device which has n input bits, 2^n output bits.
- Only 1 of the output bits is 1 for each input combination.
- Selected output corresponds to the binary value of its input; *i.e.*, if input is 3-bits with binary value of $\{0,1,1\}$ then there are 8 output lines with binary value of $\{0,0,0,1,0,0,0,0\}$.



a. A 3-bit decoder

Ex: 2-to-4 single bit decoder implementation

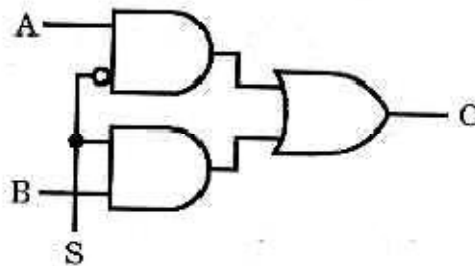
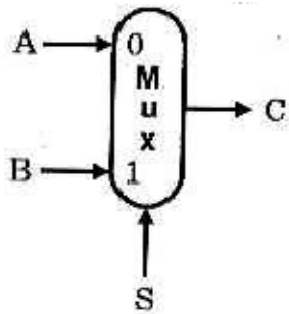


Encoder

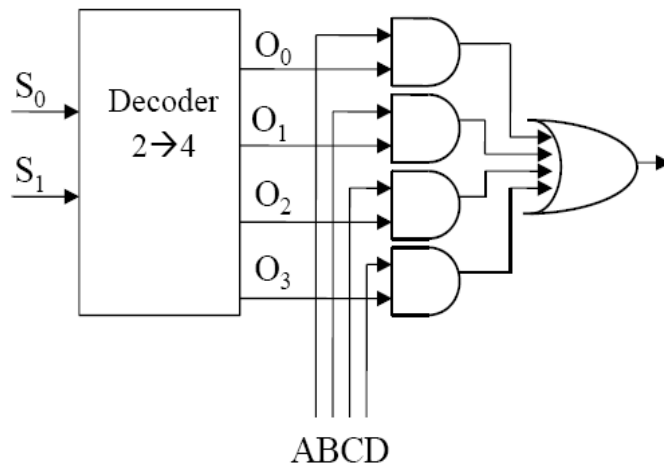
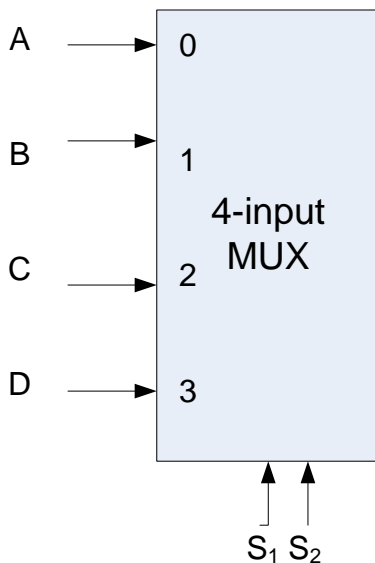
- An encoder performs the opposite of a decoder. It has 2^n inputs and n output bits.
- Whichever line is selected on the input (has a signal of 1), the corresponding binary number is presented on the output.

Multiplexor

- Multiplexors are selectors which, based on the value of the 'selector' bits, the corresponding input is placed on the output line.
- Multiplexors come in a variety of sizes, 2-input, 4-input, 8-input, etc. n inputs means $\lceil \log_2 n \rceil$ 'selector', or 'control', bits.
- Ex: 2-input multiplexor.
 - In this case, the inputs A & B are both 1-bit, the selector input S is 1-bit, and the output C is 1-bit.
 - If the selector S has value 0, then $C = A$. If $S = 1$, then $C = B$.
 - This function can be created using the *AND-OR* gate network shown on the right. Note that the Boolean expression for a multiplexor is $C = S' A + S B$.



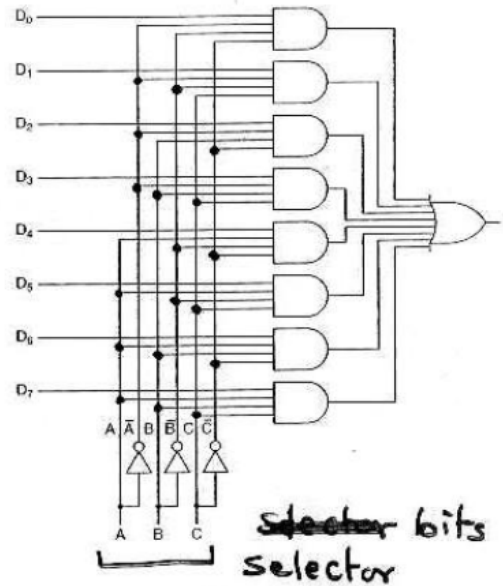
- In essence, a multiplexor is actually a decoder plus some extra gates.
 - Ex: 4 input multiplexor



Ex: 8-input multiplexor

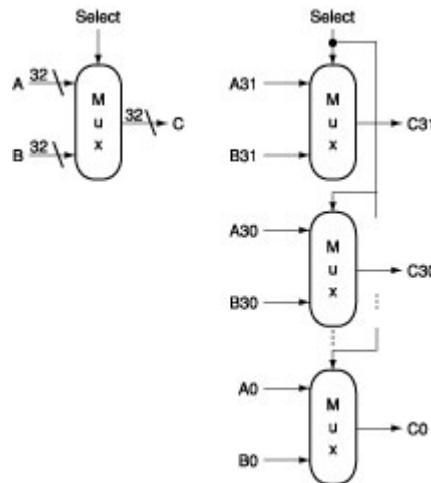
*D₀-D₇
are
inputs*

*A is S₂
B is S₁
C is S₀*



Ex: A multiplexor that selects between a pair of 32-bit buses, built as an array of 1-bit-wide multiplexors

a. A 32-bit wide 2-to-1 multiplexor

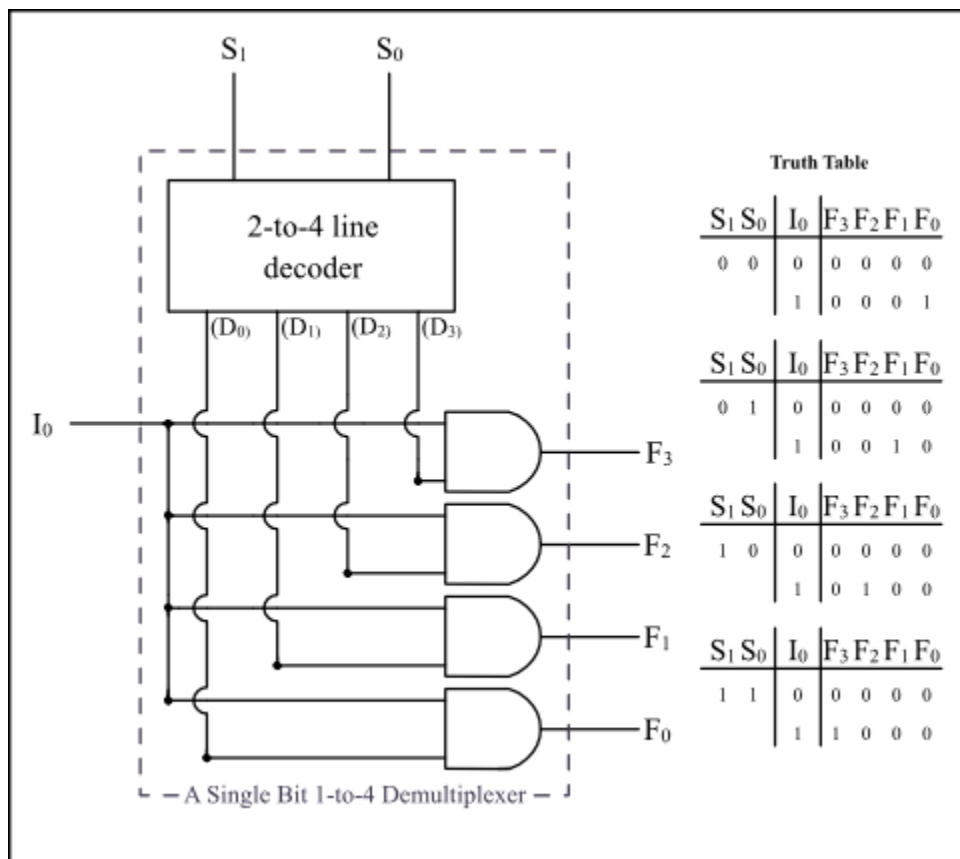


b. The 32-bit wide multiplexor is actually an array of 32 1-bit-wide multiplexors

A multiplexor is arrayed 32 times to perform a selection between two 32-bit inputs. Note that there is still only one data selection signal used for all 32 1-bit multiplexors.

Demultiplexor

- Inverse of a multiplexor.
- It connects or routes its single input to one of 2^n outputs depending on the value of the 'selector'/'control' bits.
- If the binary value of the control bits is k , then the input is connected to the k^{th} output.
- A demultiplexor is a decoder plus some extra *AND* gates. Control bits select exactly which *AND* gate to let the input value through to.



- *MUXs* (Multiplexors) and *DEMUXs* (Demultiplexors) are used for sharing resources in the computer.
 - In telecommunications, a multiplexor is a device that performs multiplexing, *i.e.*, that combines multiple analog message signals or digital data streams into one signal. (Think how your router works.)