SEE1223: Digital Electronics

4 – Medium Scale Integrated (MSI) Circuits

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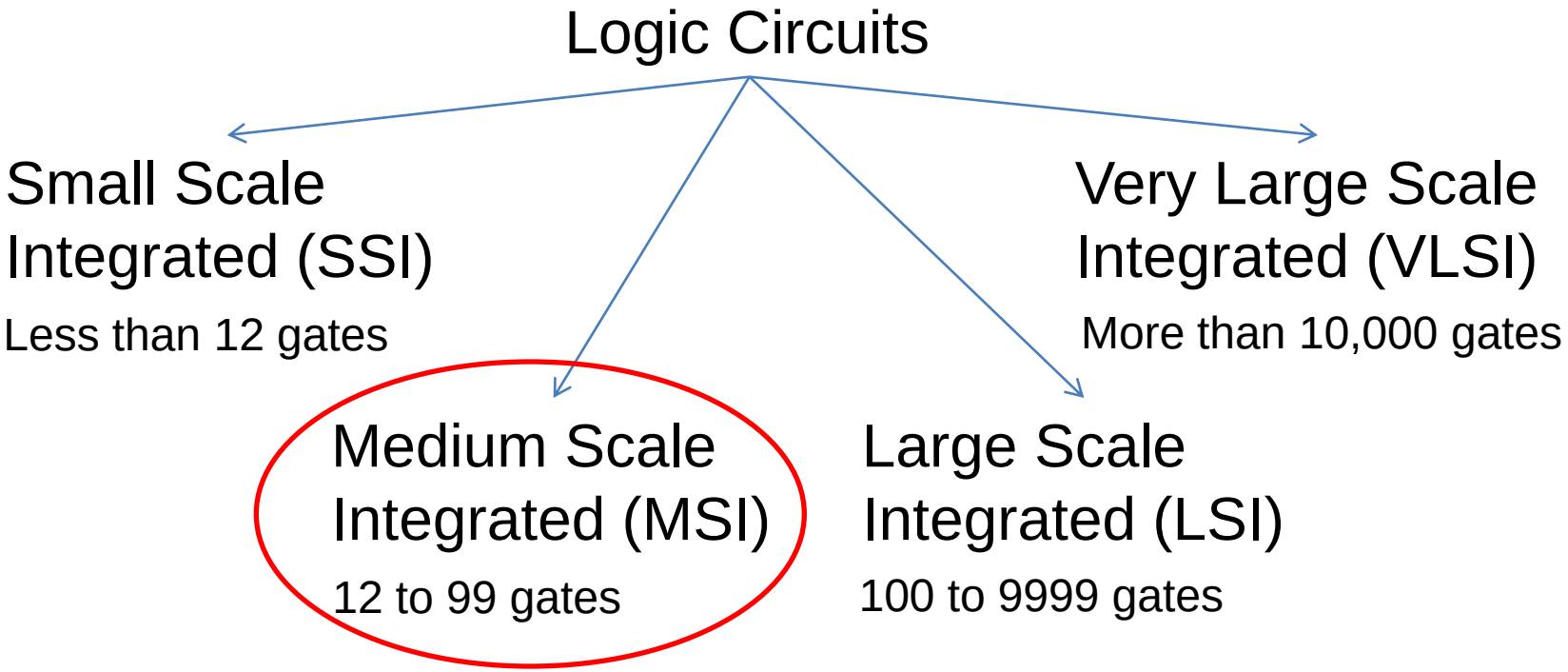
MSI Circuits

- Multiplexers (Mux)
  - 2x1, 4x1, and 8x1 muxes
  - 74x151, 74x153, 74x157 devices
  - Mux expansions
- Demultiplexers (Demux), Decoders, and Encoders
  - 74x138 and 74x139 decoders
  - Encoder, priority encoder and the 75x147 devices
  - BCD to 7-segment decoder and the 74x247 devices
  - Logic functions using muxes and decoders
- Adders and Comparators
  - Half, full and ripple carry adders
  - The 74x83 devices
  - Comparator and the 74x85 devices

MSI Circuits

- MSI (Medium Scale Integrated) circuits are logic circuits that contain 12 to 99 logic gates

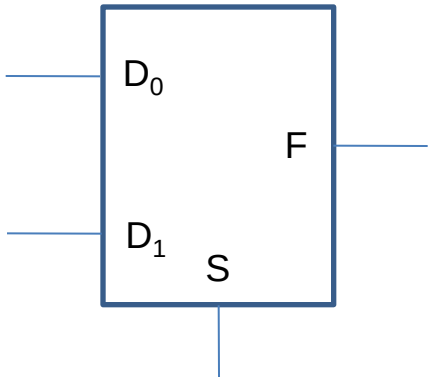


Multiplexers (Mux)

- A multiplexer (Mux) selects one data line from two or more input lines and routes data from the selected line to the output. The particular data line that is selected is determined by the select inputs.

Mux (cont.)

- 2x1 Mux (2 input data and 1 output data)



Block diagram for 2x1 mux

Function:

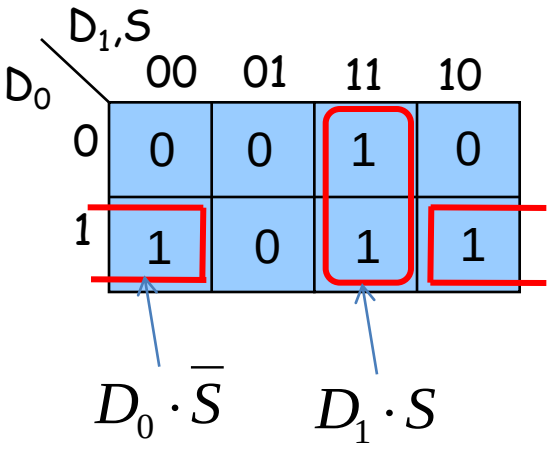
$F = D_0$ when $S = 0$
$F = D_1$ when $S = 1$

-How to design a 2x1 mux using basic gates?
- Using K-Map? What are the inputs and outputs?
- By looking at its function?

Mux (cont.)

- Design of 2x1 mux using K-Map
  - Inputs: D_0, D_1, S
  - Output: F

D_0	D_1	S	F
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	1

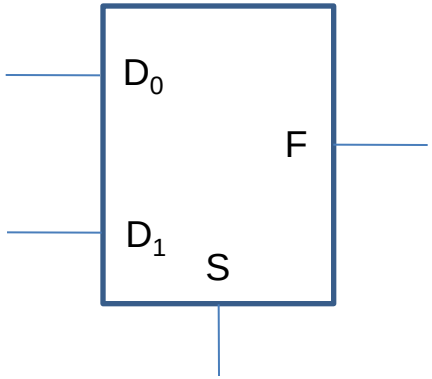


$$F = D_0 \cdot \overline{S} + D_1 \cdot S$$

Can you draw the logic circuit?

Mux (cont.)

- Design of 2x1 mux by its function



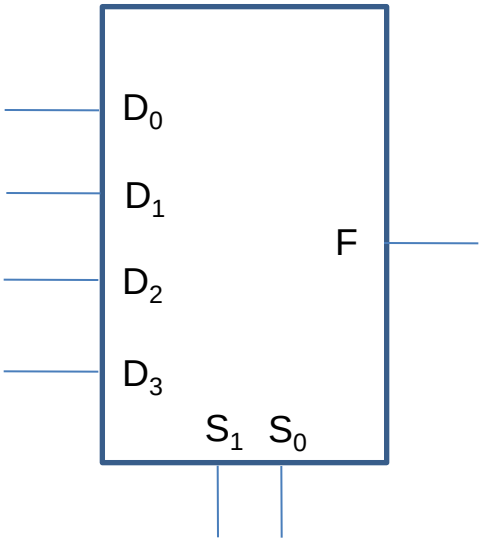
$F = D_0$ when $S = 0$ $\longrightarrow$ $F = D_0 \cdot \overline{S}$

$F = D_1$ when $S = 1$ $\longrightarrow$ $F = D_1 \cdot S$

Therefore, $F = D_0 \cdot \overline{S} + D_1 \cdot S$

Mux (cont.)

- 4x1 Mux



Function:

F = D_0 when S_1 = 0 and S_0 = 0
F = D_1 when S_1 = 0 and S_0 = 1
F = D_2 when S_1 = 1 and S_0 = 0
F = D_3 when S_1 = 1 and S_0 = 1

How can we design the 4x1 mux using basic gates?
- Using K-Maps? What are the outputs and inputs?
- By its function?

Mux (cont.)

- The 4x1 Mux has six inputs (D_3, D_2, D_1, D_0, S_1, S_0) and one output (F), therefore it is difficult/time consuming to use K-Maps

Looking at the function of the 4x1 mux,

F = D_0 when S_1 = 0 and S_0 = 0 $\longrightarrow F = D_0 \cdot \overline{S_1} \cdot \overline{S_0}$

F = D_1 when S_1 = 0 and S_0 = 1 $\longrightarrow F = D_1 \cdot \overline{S_1} \cdot S_0$

F = D_2 when S_1 = 1 and S_0 = 0 $\longrightarrow F = D_2 \cdot S_1 \cdot \overline{S_0}$

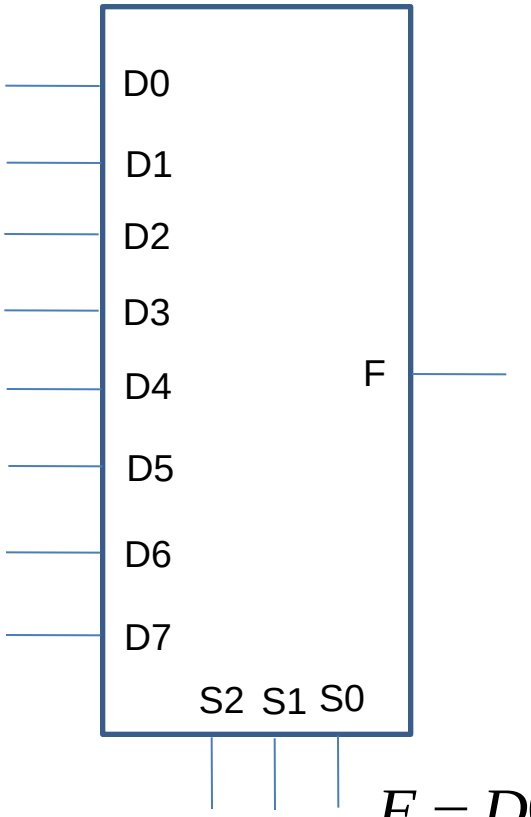
F = D_3 when S_1 = 1 and S_0 = 1 $\longrightarrow F = D_3 \cdot S_1 \cdot S_0$

Therefore, $F = D_0 \cdot \overline{S_1} \cdot \overline{S_0} + D_1 \cdot \overline{S_1} \cdot S_0 + D_2 \cdot S_1 \cdot \overline{S_0} + D_3 \cdot S_1 \cdot S_0$

Can you implement this logic function?

Mux (cont.)

- 8x1 Mux



Function:

$F = D_0$ when and $S_2 = 0$ and $S_1 = 0$ and $S_0 = 0$
$F = D_1$ when and $S_2 = 0$ and $S_1 = 0$ and $S_0 = 1$
$F = D_2$ when and $S_2 = 0$ and $S_1 = 1$ and $S_0 = 0$
$F = D_3$ when and $S_2 = 0$ and $S_1 = 1$ and $S_0 = 1$
$F = D_4$ when and $S_2 = 1$ and $S_1 = 0$ and $S_0 = 0$
$F = D_5$ when and $S_2 = 1$ and $S_1 = 0$ and $S_0 = 1$
$F = D_6$ when and $S_2 = 1$ and $S_1 = 1$ and $S_0 = 0$
$F = D_7$ when and $S_2 = 1$ and $S_1 = 1$ and $S_0 = 1$

What is the logic expression for F?

$$F = D0 \cdot \overline{S2} \cdot \overline{S1} \cdot \overline{S0} + D1 \cdot \overline{S2} \cdot \overline{S1} \cdot S0 + \ldots + D7 \cdot S2 \cdot S1 \cdot S0$$

Mux (cont.)

- Questions..
- How many select bits is needed for 16x1 mux?
  - 4 select inputs (S3, S2, S1, S0)
- How many inputs does a 32x1 mux have?
  - 5 select bits and 32 input data lines (37 inputs)

Mux IC

- Mux (and other common logic blocks) can be bought as a packaged integrated circuits (IC)
- Commonly used IC is TTL and CMOS
- For example, an 2x1 mux IC in TTL is called 74LS157 (LS for Low Speed TTL)
- 2x1 mux IC in CMOS is called 74HC157 (HC for High Speed CMOS)
- 2x1 Mux IC: 74LS157 (TTL)/74HC157 (CMOS)
- 4x1 Mux IC: 74LS153 (TTL)/74HC153 (CMOS)
- 8x1 Mux IC: 74LS151 (TTL)/74HC151 (CMOS)

Mux IC (cont.)

- Refer to datasheet for detailed descriptions of the 2x1 mux (74x157), 4x1 mux (74x153), and 8x1 mux (74x151)

Multiplexer expansion

- Smaller multiplexers can be expanded to obtain larger multiplexers
- Example 1: Design a 4x1 mux using three 2x1 mux only
- Example 2: Design a 16x1 mux using two 74x151 IC's and basic gates