Digital Circuit And Logic Design I

Lecture 6

Outline

- Decoder and encoder
  1. decoder
  2. code converter
  3. encoder
  4. priority encoder
- Multiplexer and demultiplexer
  1. multiplexer
  2. demultiplexer

Decoder and encoder
1. Decoder

- A code is a string of several bits. With an n-bit code, it is possible to represent $2^n$ unique values.
- The devices that translate the n-bit pattern into one of the $2^n$ possible values are called decoders.

Pictures from textbook Introduction to Logic design

1. Decoder (cont.)

- '138 MSI component

Pictures from textbook Digital Logic pocket data book

1. Decoder (cont.)

- 4-to-16 decoder implemented by using 3-to-8 decoders
- 5-to-32 decoder implemented by using 3-to-8 decoders and 2-to-4 decoder

Pictures from textbook Digital Logic pocket data book
1. Decoder (cont.)

- Decoders can be used to implement any function in canonical sum or canonical product form.
- All that is needed is external logic required to OR minterms for canonical sum expression or to AND maxterms for canonical product expression.

Using 3-to-8 decoder to implement logic function F and G

2. Code converter

- A code converter is a combinational circuit that translates the input code word into the corresponding new code word.
- For example, BCD-to-7-segment decoder and BCD-to-excess-3 code converter

<table>
<thead>
<tr>
<th>BCD-to-7-segment decoder</th>
<th>TIL</th>
<th>CMOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fanout 4</td>
<td>450</td>
<td>75</td>
</tr>
<tr>
<td>Excess-3 to decimal (low order)</td>
<td>450</td>
<td>75</td>
</tr>
<tr>
<td>Excess-3 to decimal (high order)</td>
<td>450</td>
<td>75</td>
</tr>
</tbody>
</table>

'47 MSI component

Pictures from text book: Introduction to Logic design

Pictures from text book: Digital Logic pocket data book
3. Encoder

- An encoder performs the reverse function of a decoder. The \(2^n\)-to-\(n\) decoder generates an \(n\)-bit code word as a function of the combination of values on its \(2^n\) inputs.
- Usually only one of the inputs is 1 and all others are 0. The output is a binary code word corresponding to the input.
- Because encoders can be built easily, encoder ICs are not available as off-the-shelf components.

4. Priority encoder

- If more than one input is 1 at any time, the encoder generally will not produce a valid output.
- Nevertheless, there are exceptions. The so-called priority encoders allow more than one of their inputs to be active at any time.
- Each input has priority assigned to it. The code word produced as the output corresponds to that of the highest-priority input among all the inputs that are active.

Multiplexer and demultiplexer
1. Multiplexer

- Multiplexing is the process of channeling information from one of several sources to a single destination.
- A multiplexer (selector) is thus a switch connecting one of its several inputs to the output. A set of \( n \) control inputs is needed to select one of the \( 2^n \) inputs.

![Multiplexer Diagram]

1. Multiplexer (cont.)

- Multiplexers can be stacked to produce \( 2^n \)-to-1 multiplexer.

![16-to-4 Multiplexer Diagram]

- For example, \( F = \Sigma_{A,B,C}(2,3,5,7) \)
- It is possible to reduce the number of input on the multiplexer to implement this function.
- We can partition the truth table based on the values of \( B \) and \( C \) (this is often called folded-table method).

![Folding Table Diagram]
1. Multiplexer (cont.)

<table>
<thead>
<tr>
<th>Minterm</th>
<th>ABC</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>000</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>001</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>010</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>011</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>101</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>110</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>111</td>
<td>0</td>
</tr>
</tbody>
</table>

\[ F = \begin{cases} 0 & \text{if } A = \text{Minterm} \\ A' & \text{otherwise} \end{cases} \]

Pictures from text book
Introduction to Logic design

2. Demultiplexer

- Demultiplexing is the reverse of multiplexing. That is, a demultiplexer (distributor) distributes its input signal to one of its several outputs.
- In fact, a decoder with an enable input can be used as a demultiplexer.

Pictures from Introduction to Logic design