CS 240 Lab 3
Combinational Circuits

- **Review of Two's Complement and Overflow**
- **Multiplexer/Demultiplexer**
- **Decoder/Encoder**

Two's Complement and Overflow

Given n bits, the range of binary values which can be represented using

Unsigned representation: $0 \rightarrow 2^n - 1$

Signed representation: $-2^{n-1} \rightarrow 2^{n-1} - 1$, MSB is used for sign

Two's Complement (signed representation):

Most significant /leftmost bit (0/positive, 1/negative)

Example: given a fixed number of 4 bits:

1000_2 is negative.

0111_2 is positive.

Overflow

Given a fixed number of n available bits:

Overflow occurs if a value cannot fit in n bits.

Example: given 4 bits:

The largest negative value we can represent is -8_{10} (1000_2)

The largest positive value we can represent is $+7_{10}$ (0111_2)

Overflow in Addition

When adding two numbers with the same sign which each can be represented with n bits, the result may cause an overflow (not fit in n bits).

An overflow occurs when adding if:

- Two positive numbers added together yield a negative result, or
- Two negative numbers added together yield a positive result, or
- The Cin and Cout bits to the most significant pair of bits being added are not the same.

An overflow cannot result if a positive and negative number are added.

Example: given 4 bits:

0111_2

$+\ 0001_2$

1000_2 overflow NOTE: there is not a carry-out!

In two's complement representation, a carry-out does not indicate an overflow, as it does in unsigned representation.

Example: given 4 bits,

1001_2 (-7_{10})

$+\ 1111_2$ (-1_{10})

$1\ 1000_2$ (-8_{10}) no overflow, even though there is a carry-out

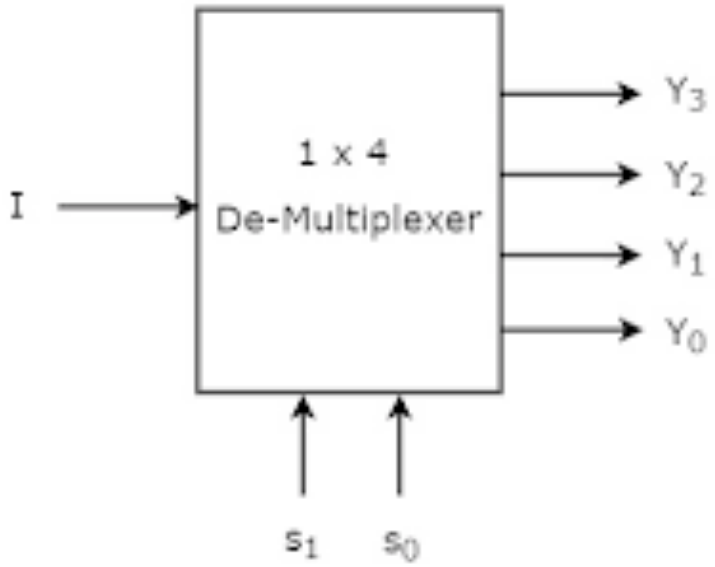
Demultiplexer

Opposite of multiplexer

Single input data line

Input through to a single one of the 2^n output lines

Output line is determined by the n select inputs



S1	S0	I	Y3	Y2	Y1	Y0
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

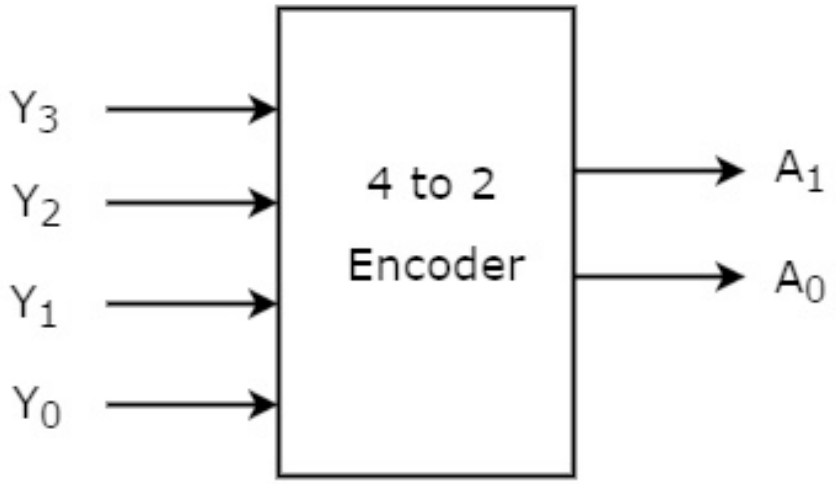
Encoder

Opposite of decoder

2^n inputs - only 1 of the inputs can be active at a time

Input selected specifies a decimal number which corresponds to the number of the input (3, 2, 1, or 0)

n outputs represent the corresponding binary representation of the decimal value specified by the input



Y3	Y2	Y1	Y0	A1	A0
0	0	0	1		
0	0	1	0		
0	1	0	0		
1	0	0	0		