University of Illinois at Urbana-Champaign
Dept. of Electrical and Computer Engineering

ECE 120: Introduction to Computing

Decoders

How Can We Decode a Representation?

What if we have
- designed a representation using **N** bits,
- and have an **N-bit** value in that representation,
- but need separate signals for each of the 2^N possible bit patterns?

Applications include
- **naming sets of bits**, which we explore in 3-4 weeks, when we examine memory, and
- **generating arbitrary functions dynamically**, a technique used for many years in reconfigurable hardware devices.

A Decoder's Outputs Have Exactly One 1 Bit

In other words,
- **given a set of N bits**,
- we want to **generate a signal for each possible combination** of the **N** bits.

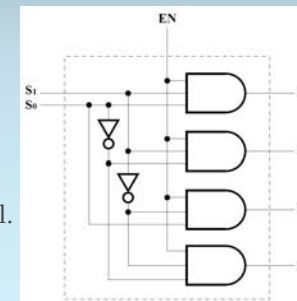These **signals correspond to the minterms** on the **N** bits.

Exactly one of the resulting signals **has the value 1**.

A 2-to-4 Decoder with Enable Produces Zero or One 1 Bit

We call the logic to perform such a task a **decoder**.

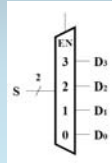An example of a **2-to-4 decoder** is shown to the right.

The decoder here has an enable signal. If **EN = 0**, all outputs are 0.

A Trapezoid that Widens Represents a Decoder

The symbolic form for a decoder is a trapezoid.

- The **N-bit** signal to be decoded enters from the smaller side.
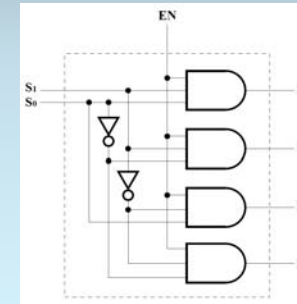- The 2^N outputs exit from the larger side.

If the decoder has an enable signal, it is typically drawn on a small side of the trapezoid.

Decoders and Muxes Both Calculate All Minterms

Notice that the internal structure of a decoder looks similar to that of a mux.
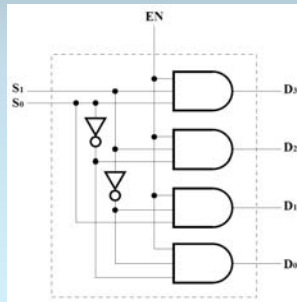

In a mux, minterms are combined with per-minterm inputs and ORed together in a single output.

Decoder Outputs Allow Separate Use of Each Minterm

The decoder allows the minterm signals to be used separately.

For example, each decoder output might control the mechanical release for a different product in a vending machine.

Early Reconfigurable Hardware Used Decoders

Or we can use a decoder
- to compose arbitrary functions on the inputs
- by ORing together the right set of minterms.

Doing so is equivalent to composing a function with a mux by connecting 0s and 1s to its inputs.

But a single decoder can be used construct many functions, while the mux allows only one function.

Such an approach allowed
- programmable logic arrays (PLAs)
- to dynamically produce arbitrary functions,
- thus providing reconfigurable hardware.