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.

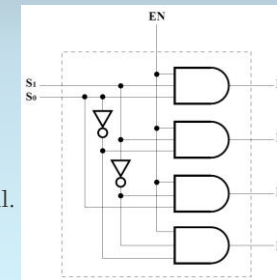**Exactly one** of the resulting
signals **has the value 1**.

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.
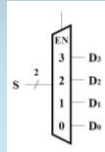If **EN = 0**, all
outputs are 0.

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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.

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Decoders and Muxes Both Calculate All Minterms

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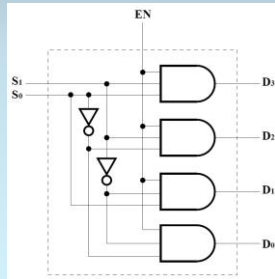a mux.

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

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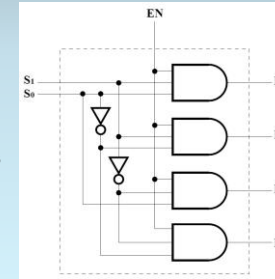
Decoder Outputs Allow Separate Use of Each Minterm

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.

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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.

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