Electronics

Logic Gates: Tri-State Output

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Types of logic gate outputs

- Totem pole
Types of logic gate outputs

- Totem pole
  - Output is **HIGH** or **LOW**.

- Open collector
  - Output is floating or **LOW**.

- Tri-state outputs combine these
  - Output can be **HIGH**, **LOW**, or floating

This requires two inputs; input and select.
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Three types of outputs
- Tri-state output
- Tri-state output equivalent circuit
- Tri-state output (inverting)
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  **select**.
Tri-state outputs

![Tri-state output equivalent circuit diagram]

input select output

Input is to make output LOW or HIGH, select is to make output float or follow input.
Tri-state outputs

- **input** is to make output LOW or HIGH,

![Tri-state output diagram](image)
Tri-state outputs

- **input** is to make output LOW or HIGH,
- **select** is to make output float or follow input
Tri-state output equivalent circuit
The **select** determines whether the output is floating or not.
Types of logic gate outputs
Microprocessor buses
Determining whether a pin is floating

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input

select

output
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Tri-state output (inverting)
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Gates can be inverting, like other gates.
Microprocessor buses

- A **bus** is created if several tristate devices are connected together.
- As long as only one is selected at a time, there is no problem.
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Tri-state (I/O) pins

\[ \text{name} \]

The direction input indicates output or input (i.e. floating).
Tri-state (I/O) pins

- Tri-state pins allow input and output on the same pin.
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Tri-state buses

- Tri-state buses allow several devices to input and output on the same lines.
- Uses I/O signal and address decoding
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Internal view (CMOS)

Here’s what a CMOS tri-state output looks like inside. (Note the top transistor is turned on by a low, but the bottom transistor is turned on by a high.)
Internal view (CMOS)

When output is enabled, and data out is low, the output will be low. (Only bottom transistor on.)
Internal view (CMOS)

When output is enabled, and data out is high, the output will be high. (Only top transistor on.)
When output is not enabled, the output will float (to become an input). (Both transistors off.)
Determining whether a pin is floating

If a pin is supposed to be HIGH, you can measure the voltage and see if it is above $V_{OH_{\text{min}}}$. If a pin is supposed to be LOW, you can measure the voltage and see if it is below $V_{OL_{\text{max}}}$.
Determining whether a pin is floating

- If a pin is supposed to be HIGH, you can measure the voltage and see if it is above $V_{OH_{min}}$. 

If a pin is supposed to be LOW, you can measure the voltage and see if it is below $V_{OL_{max}}$. 

How can you tell if it is floating?
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How can you tell if it is floating?
What should $V_{out}$ be?
What should $V_{out}$ be if it is tied to the output of a gate?
What should $V_{out}$ be if the gate output is HIGH?
What should $V_{out}$ be if the gate output is LOW?
Should $V_{out}$ depend on the value of $R$?