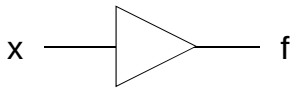
ECE380 Digital Logic

Implementation Technology:
Buffers, Tri-state gates,
Transmission gates

Buffers

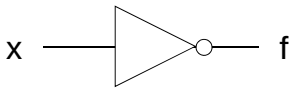
- In circuits where a logic gate has to drive a large capacitive load, ***buffers*** are often used to improved performance
- Buffers can be created with different amounts of drive capability (depending on the size of the transistors used to construct them)
  - Larger transistors => more current handling capability
  - A common use of a buffer is to control a light-emitting diode (LED)
- Buffers have greater ***fan-out*** than other (regular) logic gates

Buffers



f=x

A non-inverting buffer

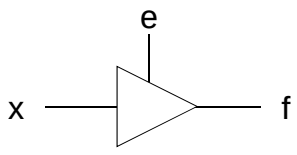


f=x'

An inverting buffer

Tri-state Buffers (Gates)

- A tri-state buffer (gate) has
  - One input (x)
  - One output (f)
  - One control input (e)

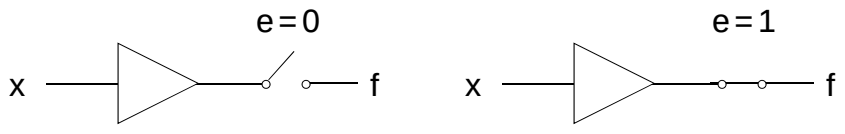


f=x if e=1

A tri-state buffer

Tri-state Buffers (Gates)

- When e=1, the buffer drives the value of x onto f, causing f=x
- When e=0, the buffer is completely disconnected from the output f



Equivalent circuit

Tri-state Buffers (Gates)

- In truth table form,

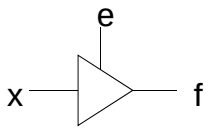
e	*x*	*f*
0	0	Z
0	1	Z
1	0	0
1	1	1

- For the rows where e=0, the output is denoted by the logic value Z
- This Z is called the high-impedance state
- The name tri-state derives from the fact that there are two normal states for a logic signal (0 and 1) and Z represents a third state that has no output

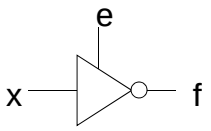
Four type of tri-state buffers

- There are four possible configurations of tri-state buffers
  - based on two types of outputs
    - Inverting and non-inverting outputs
  - and two types of control signals (e)
    - Active high and active low enables
- Active low enables implies the output is active (f=x) when the enable is low (e=0)

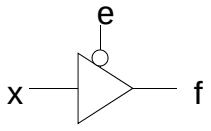
Four type of tri-state buffers



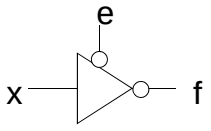
e	*x*	*f*
0	0	Z
0	1	Z
1	0	0
1	1	1



e	*x*	*f*
0	0	Z
0	1	Z
1	0	1
1	1	0

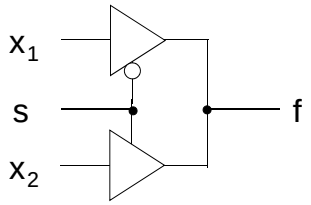


e	*x*	*f*
0	0	0
0	1	1
1	0	Z
1	1	Z



e	*x*	*f*
0	0	1
0	1	0
1	0	Z
1	1	Z

Tri-state buffer application

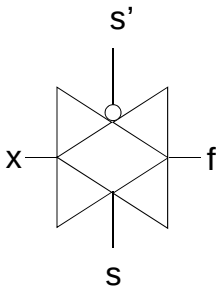


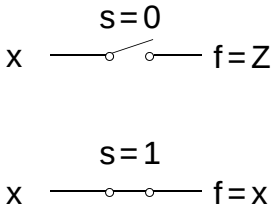
s	x1	x2	f
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

- Note the outputs of the tri-state gates are wired together
  - This is possible only because we know that (in this configuration) one or the other of the tri-state gates will be in the high impedance (Z) state
  - This type of wired connection is not possible with ordinary logic gates

Transmission gate

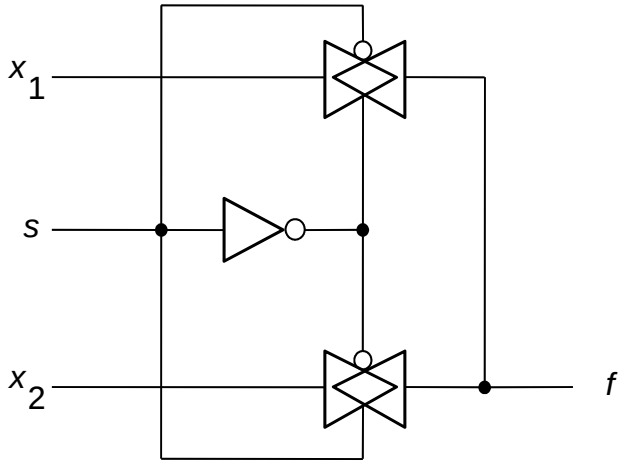
- A ***transmission gate*** acts as a switch, connecting an input (x) to an output (f)
  - Commonly used to implement XOR gate and multiplexer circuits





s	*f*
0	Z
1	x

Multiplexer with transmission gates



XOR with transmission gates