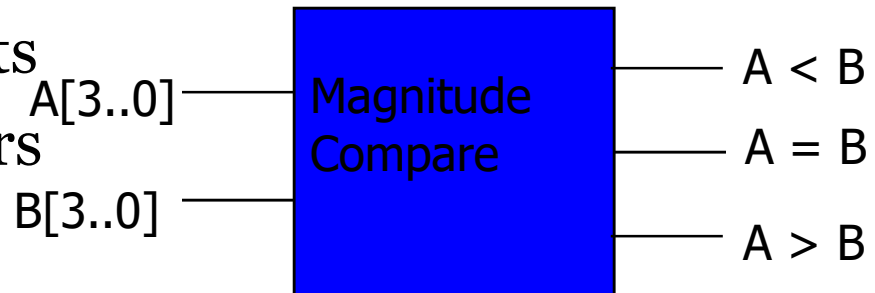


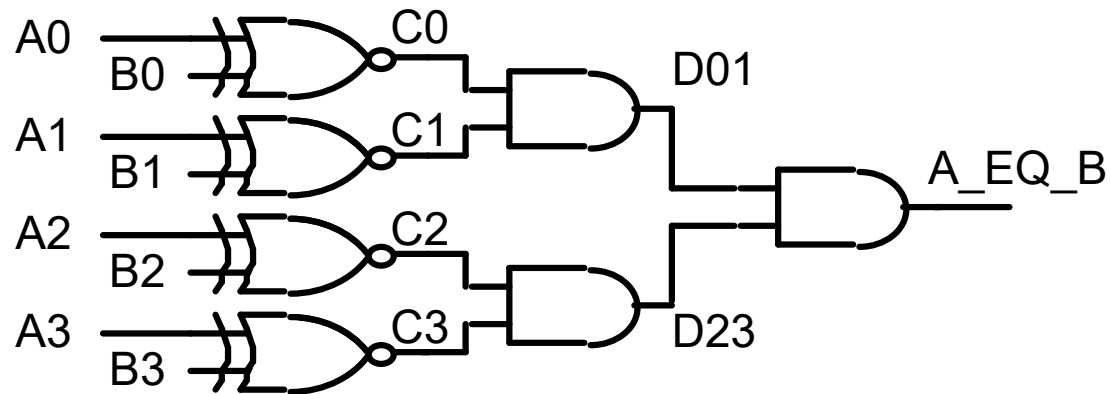
Combinational Circuit Design (Magnitude Comparator)

Magnitude Comparator

- The comparison of two numbers
 - outputs: $A > B$, $A = B$, $A < B$
- Design Approaches
 - the truth table
 - 2^{2n} entries - too cumbersome for large n
 - use inherent regularity of the problem
 - reduce design efforts
 - reduce human errors



Magnitude Comparator

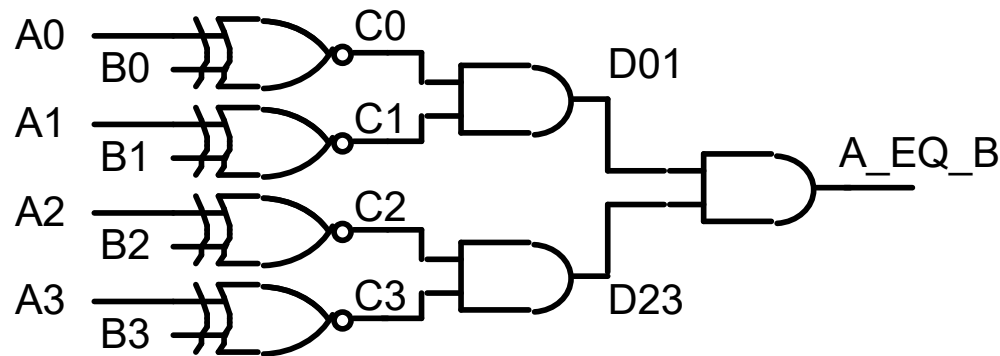


How can we find $A > B$?

How many rows would a truth table have?

$$2^8 = 256$$

Magnitude Comparator



Find $A > B$

If $A = 1001$ and
 $B = 0111$
is $A > B$?
Why?

Because $A_3 > B_3$
i.e. $A_3 \cdot B_3' = 1$

Therefore, one term in the
logic equation for $A > B$ is
 $A_3 \cdot B_3'$

Magnitude Comparator

If A = 1010 and
B = 1001
is A > B?
Why?

$$A > B = A_3 \cdot B_3' \\ + C_3 \cdot A_2 \cdot B_2' \\ + \dots$$

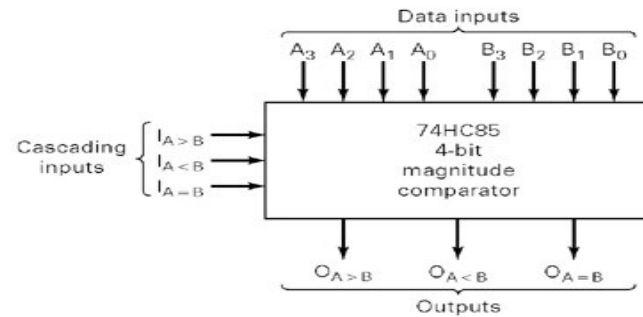
Because $A_3 = B_3$ and
 $A_2 = B_2$ and
 $A_1 > B_1$
i.e. $C_3 = 1$ and $C_2 = 1$ and
 $A_1 \cdot B_1' = 1$

Therefore, the next term in the
logic equation for A > B is
 $C_3 \cdot C_2 \cdot A_1 \cdot B_1'$

Magnitude Comparison

- Algorithm -> logic
 - $A = A_3A_2A_1A_0$; $B = B_3B_2B_1B_0$
 - $A=B$ if $A_3=B_3$, $A_2=B_2$, $A_1=B_1$ and $A_0=B_0$
- Test each bit:
 - equality: $x_i = A_iB_i + A_i'B_i'$
 - $(A=B) = x_3x_2x_1x_0$
- More difficult to test less than/greater than
 - $(A>B) = A_3B_3' + x_3A_2B_2' + x_3x_2A_1B_1' + x_3x_2x_1A_0B_0'$
 - $(A<B) = A_3'B_3 + x_3A_2'B_2 + x_3x_2A_1'B_1 + x_3x_2x_1A_0'B_0$
 - Start comparisons from **high-order** bits
- Implementation
 - $x_i = (A_iB_i' + A_i'B_i)'$

Magnitude Comparison



TRUTH TABLE

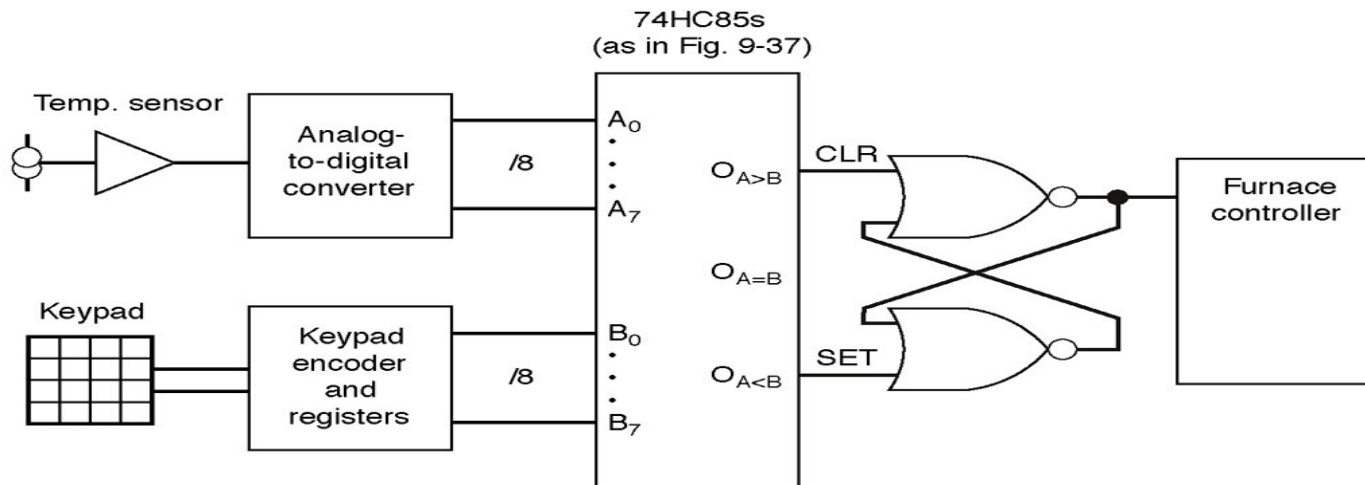
COMPARING INPUTS				CASCADING INPUTS			OUTPUTS		
A ₃ , B ₃	A ₂ , B ₂	A ₁ , B ₁	A ₀ , B ₀	I _{A>B}	I _{A<B}	I _{A=B}	O _{A>B}	O _{A<B}	O _{A=B}
A ₃ > B ₃	X	X	X	X	X	X	H	L	L
A ₃ < B ₃	X	X	X	X	X	X	L	H	L
A ₃ = B ₃	A ₂ > B ₂	X	X	X	X	X	H	L	L
A ₃ = B ₃	A ₂ < B ₂	X	X	X	X	X	L	H	L
A ₃ = B ₃	A ₂ = B ₂	A ₁ > B ₁	X	X	X	X	H	L	L
A ₃ = B ₃	A ₂ = B ₂	A ₁ < B ₁	X	X	X	X	L	H	L
A ₃ = B ₃	A ₂ = B ₂	A ₁ = B ₁	A ₀ > B ₀	X	X	X	H	L	L
A ₃ = B ₃	A ₂ = B ₂	A ₁ = B ₁	A ₀ < B ₀	X	X	X	L	H	L
A ₃ = B ₃	A ₂ = B ₂	A ₁ = B ₁	A ₀ = B ₀	H	L	L	H	L	L
A ₃ = B ₃	A ₂ = B ₂	A ₁ = B ₁	A ₀ = B ₀	L	H	L	L	H	L
A ₃ = B ₃	A ₂ = B ₂	A ₁ = B ₁	A ₀ = B ₀	X	X	H	L	L	H
A ₃ = B ₃	A ₂ = B ₂	A ₁ = B ₁	A ₀ = B ₀	L	L	L	H	H	L
A ₃ = B ₃	A ₂ = B ₂	A ₁ = B ₁	A ₀ = B ₀	H	H	L	L	L	L

H = HIGH Voltage Level
 L = LOW Voltage Level
 X = Immaterial

Magnitude Comparator

Real-world application

- Thermostat controller



Summary

- Magnitude comparators allow for data comparison
 - Can be built using and-or gates
- Greater/less than requires more hardware than equality