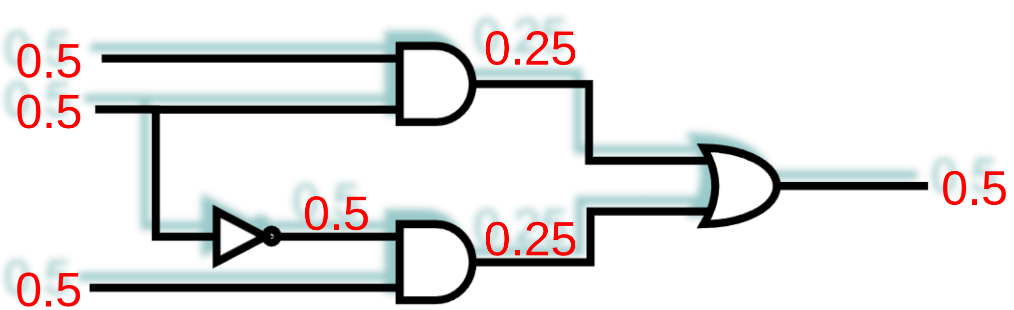
Testability Measure

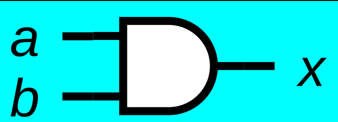
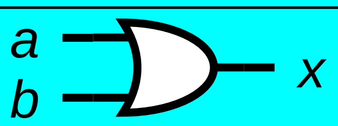
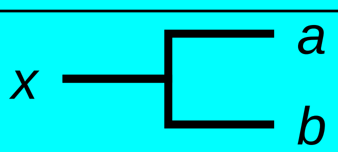
- Introduction
- SCOAP (1979)
- **<u>COP (1984)</u>**
- High-level testability measures
- Conclusion



COP

- ***Signal probability* of *x*** = **probability of *x* being logic 1**
  - **Actual signal probability requires exhaustive simulation**
  - **Hard to obtain in practice**
- **COP = Controllability/Observability Program [Brglez 84]**
  - **Fast algorithm to estimate signal probability**
  - **C_x = estimated prob(x = *1*)**
  - **$1-C_x$ = estimated prob(x = 0)**
  - **O_x = estimated probability of *fault effect* in *x* being observed at PO**
- **C_x and O_x are numbers between 0 and 1**
  - ***Larger number* means *easier* to control or observe**
- **Assumptions**
  - **1. Ignore fanout reconvergence for fast run time**
  - **2. PI are independent random numbers: ½ zero and ½ one**

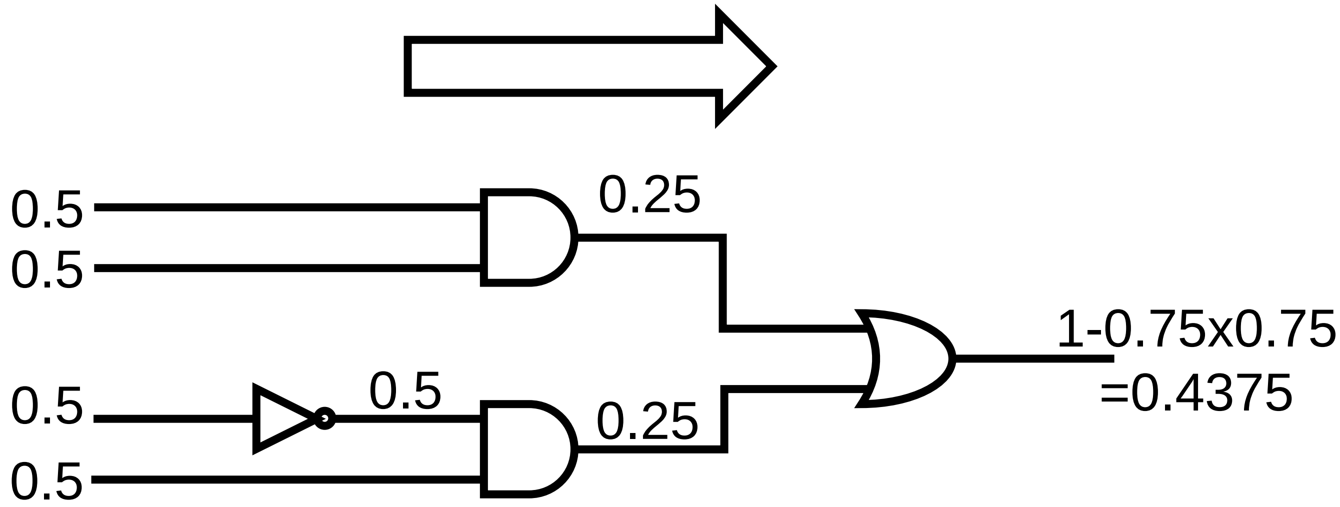
COP

	C_x	O_a
x = PI	*0.5*	
x = PO		*0.5*
	$C_x = C_a \times C_b$	$O_a = O_x \times C_b$
	$C_x = 1 - (1- C_a) \times (1- C_b)$	$O_a = O_x \times (1- C_b)$
	$C_x = C_a = C_b$	$O_x = 1 - (1- O_a) \times (1- O_b)$

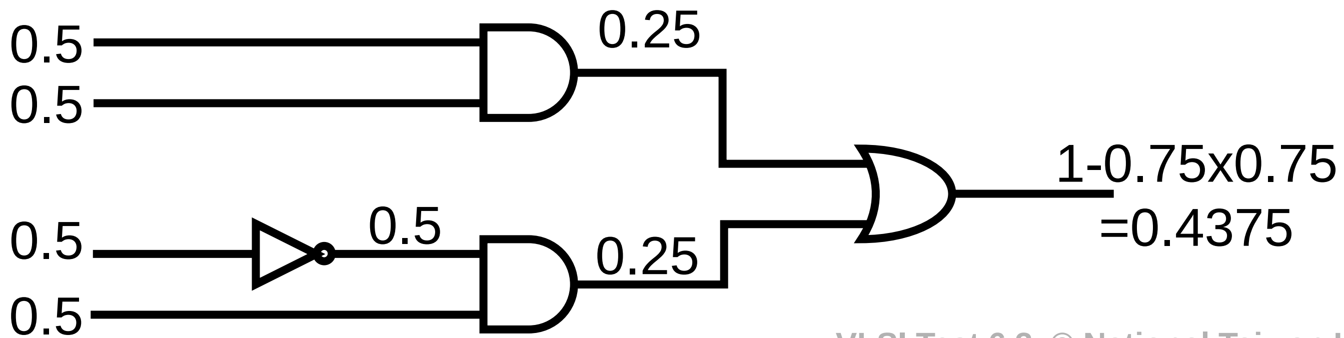
Example – Controllability

- **Calculate from PI to PO**
- **Fanout-free circuit, COP = actual signal probability**

COP C_x



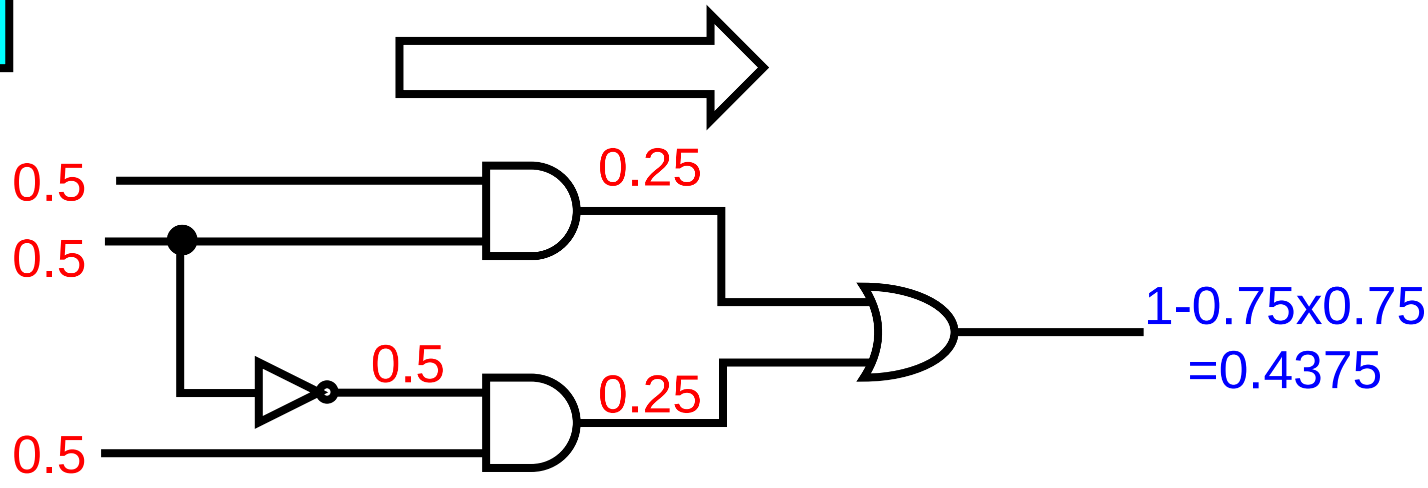
Actual signal probability



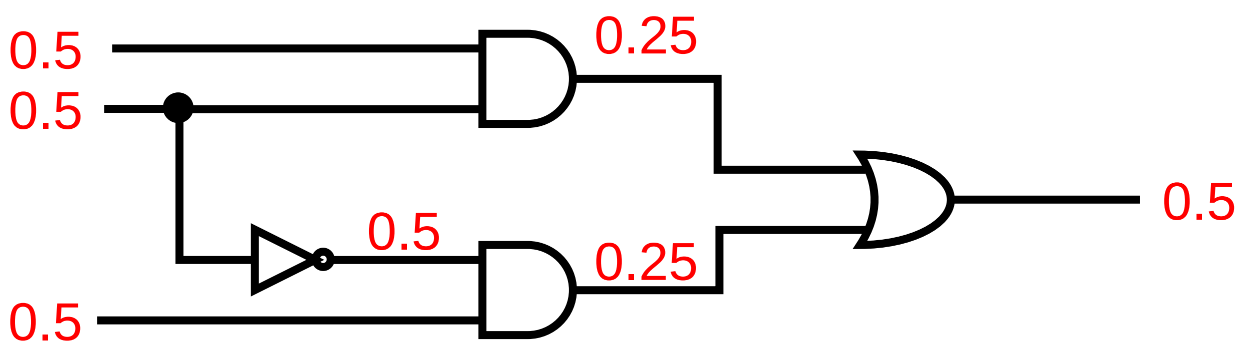
Example (2) – Controllability

- When **fanouts reconverge**, COP ≠ actual signal probability

COP C_x

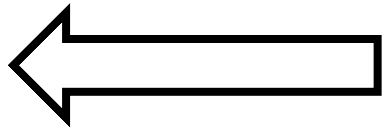


Actual signal probability

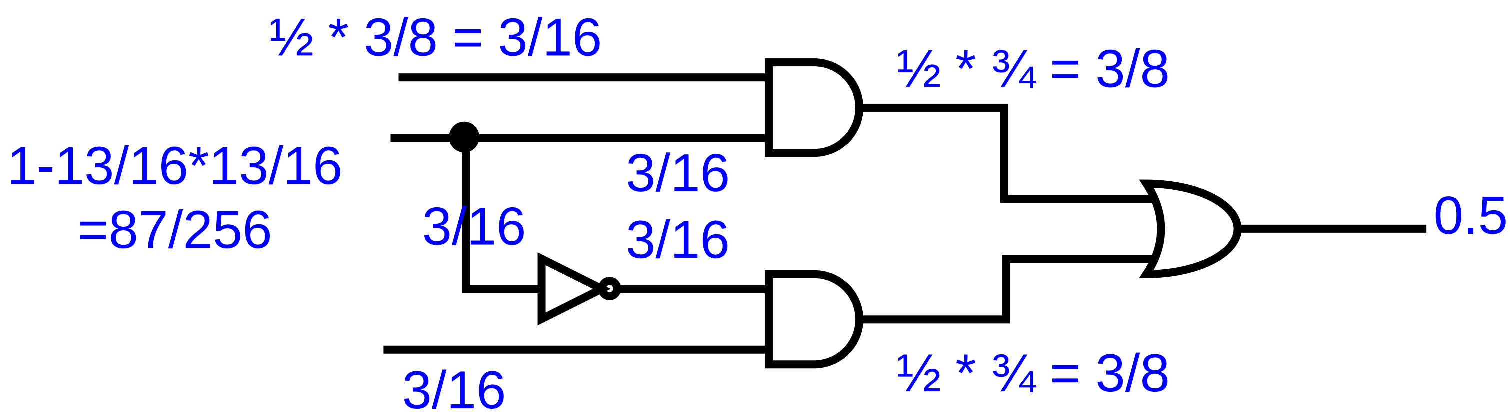


Example (2) – Observability

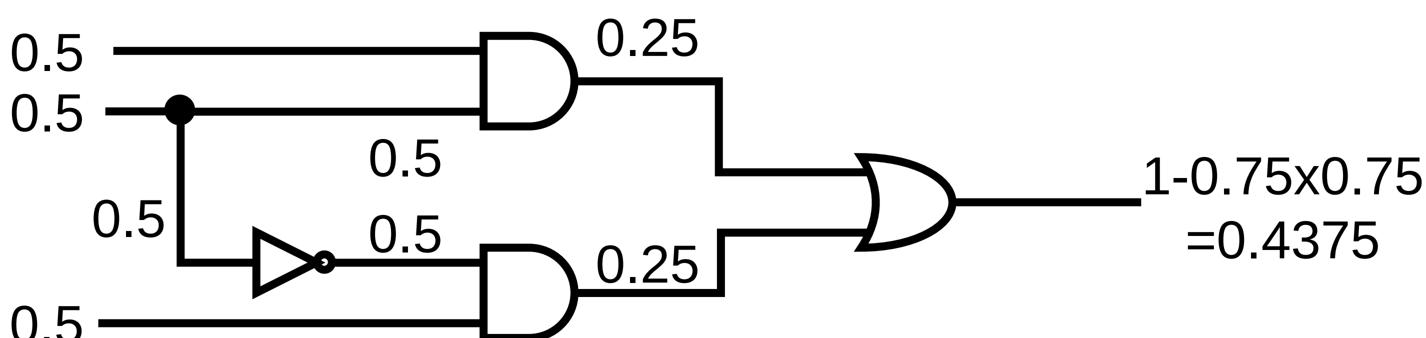
- **Calculate from PO to PI**



COP O_x



COP C_x

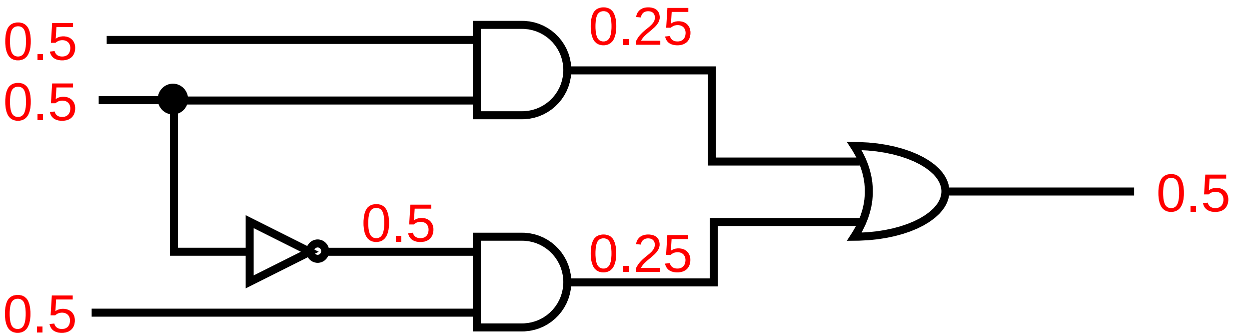


Quiz

Q: verify actual signal probability by exhaustive test patterns

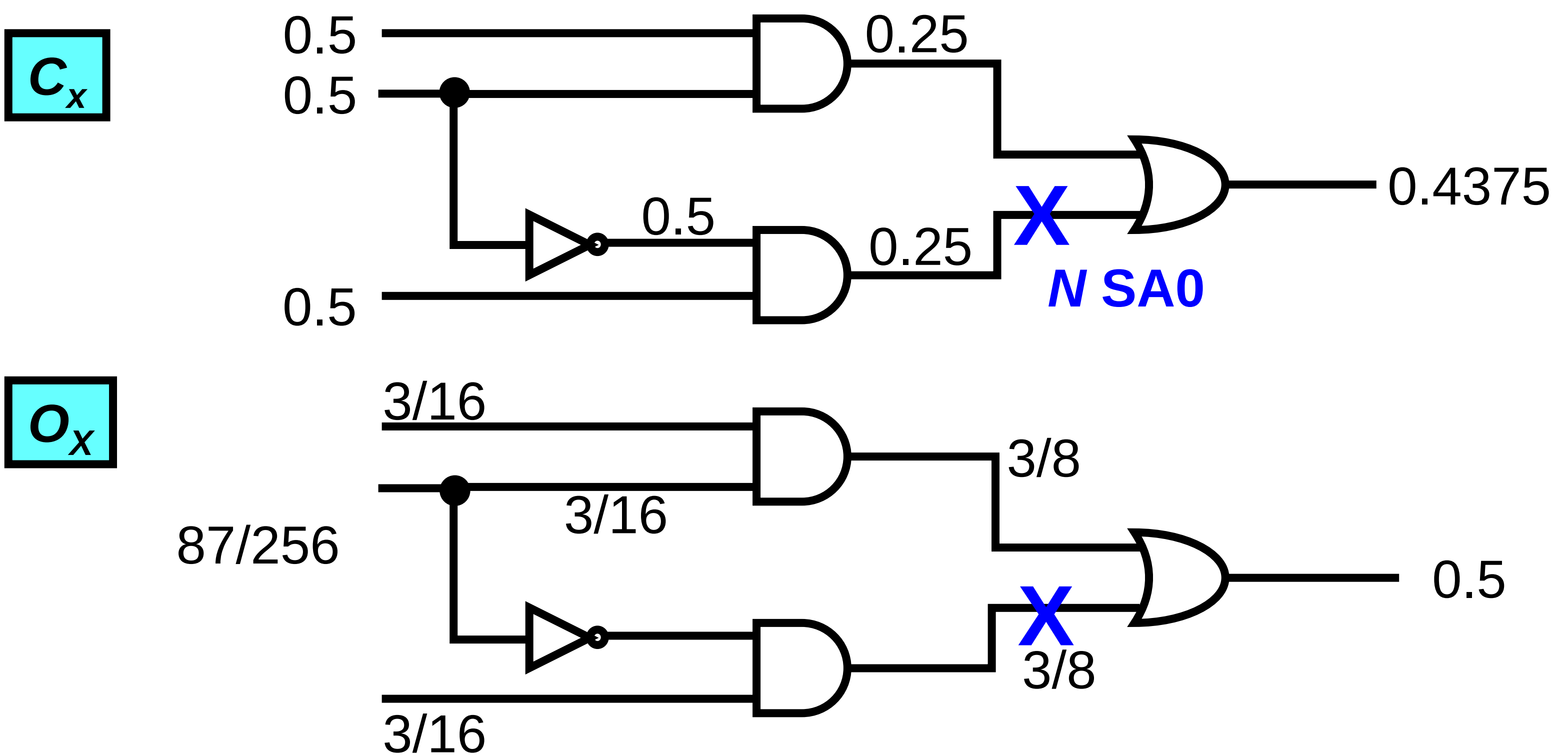
input	output
000	
001	
010	
011	
100	
101	
110	
111	

Actual signal probability



Detection Probability, DP

- ***DP$_f$*** = Probability of detecting a fault *f*
  - $DP_{N\ SA0} = C_N \times O_N$
  - $DP_{N\ SA1} = (1-C_N) \times O_N$
- **Larger *DP$_f$* means *easier* to detect fault *f***
- **Example: $DP_{N\ SA0}$ = 1/4 x 3/8 =3/32**

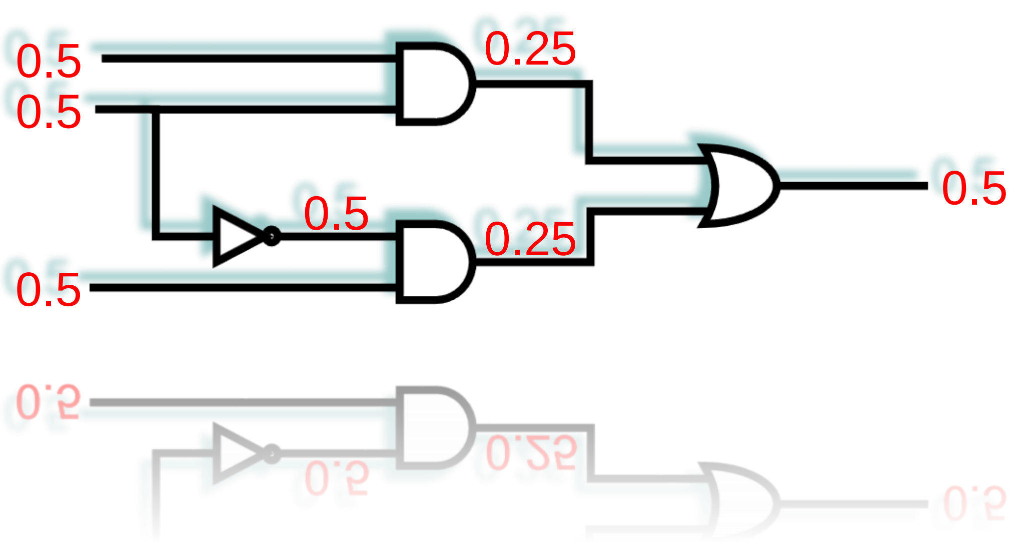


Random Pattern Resistant Faults

- **RPRF = Faults that are difficult to be tested by random patterns**
  - ***Low detectability***
  - **aka. *Hard-to-detect faults, difficult faults***
- **Example:**
  - **stuck-at-0 fault at an *n*-input AND gate output**
  - **Need test pattern (1,1,1,…1)**
  - **Assume equal signal probability of 0.5 at each input**
    - $C_x = 0.5^n$
- **Test generation for RPRF is difficult**
  - **Solutions:**
    - **1. Insert test points (See DFT lecture)**
    - **2. Weighted random patterns (see BIST lecture)**

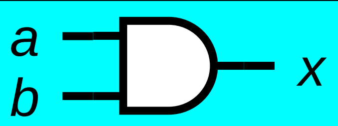
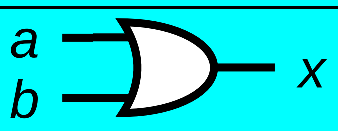
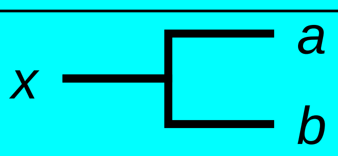
Summary

- **COP**
  - **C_x = estimated prob(x = *1*)**
  - **1-C_x = estimate prob(x = 0)**
  - **O_x = estimated probability of *fault effect* in *x* being observed**
  - **COP ≠ actual signal probability because fanout reconvergence**



FFT

- **Q: Why observability at PO is 0.5, not 1?**

	C_x	O_a
***x* = PI**	***0.5***	
***x* = PO**		***0.5***
	$C_x = C_a \times C_b$	$O_a = O_x \times C_b$
	$C_x = 1 - (1- C_a) \times (1- C_b)$	$O_a = O_x \times (1- C_b)$
	$C_x = C_a = C_b$	$O_x = 1 - (1- O_a) \times (1- O_b)$