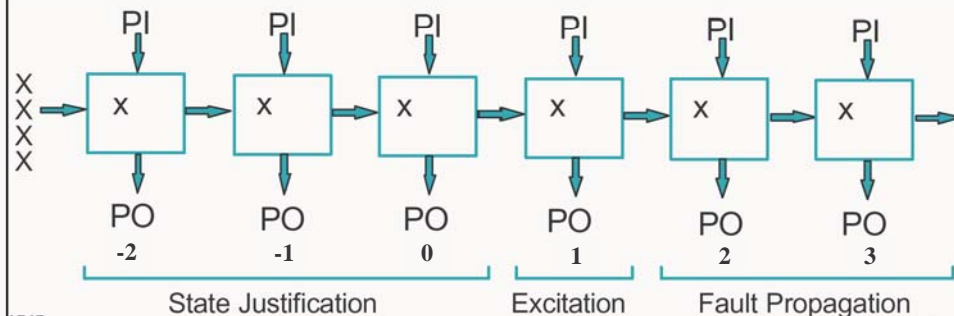


## DIGITAL SYSTEM TESTING COE -545

### Lecture – 15 Test Generation for Sequential Circuit

#### Sequential ATPG

- **Initial state is Unknown**
- *Initial State =  $xx\dots x$*
- Three main components of sequential circuit test generation (not in order):
  - Excite the fault in one Time Frame (Labeled 1 Say)
  - Propagate the fault effects Forwards (in Time) to a PO if possible or to a State (Secondary) Variable → Requires  $r \geq 1$  Frames
  - Justify the state with **backward** propagation Using p Frames (Frames 0, -1, -2, ...-(p-1))
  - Stop when All State Variables are all  $x$ 's



## Sequential ATPG

- **Initial state is Unknown**

```

r = 1
p = 0
repeat
  begin
    Build model with  $p+r$  time frames
    Ignore POs in the first  $p+r-1$  frames
    Ignore the  $q+$  outputs in the last frame
    If (test generation success) and every  $q$  input in the first
    frame has value  $xthen return SUCCESS
    Increment  $r$  or  $p$ 
  end
until ( $r + p = fmax$ )
return FAILURE$ 
```

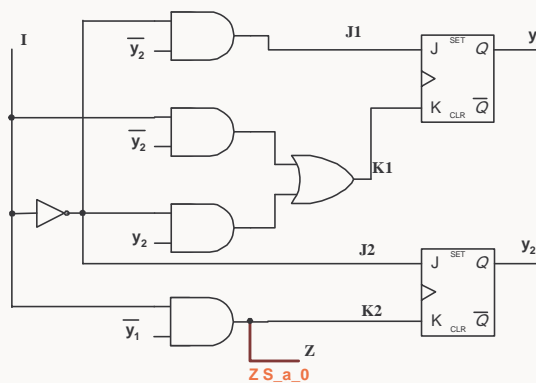
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## Example

- Consider the Fault Z/0
- Use Pseudo JK-FF (PJKFF)
- Singular Covers of the PJKFF and Propagation D-Cubes need to be Derived



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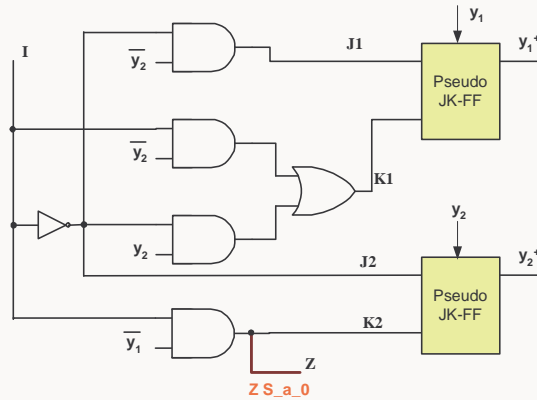
### Example

- Pseudo JK-FF Implements the Function

$y^+ = J y' + K' y$

#### Time Frame 1

- Only Test to Detect Fault is: **(I, y<sub>1</sub>)= 10**
- Only one Frame (r =1) is Thus Needed to Propagate the Fault to the PO (Z)
- Need to **Justify y<sub>1</sub>=0** → (p > 0)



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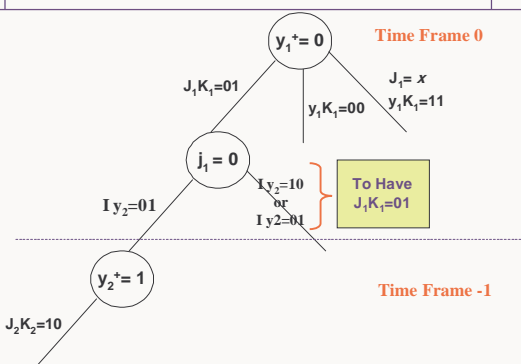
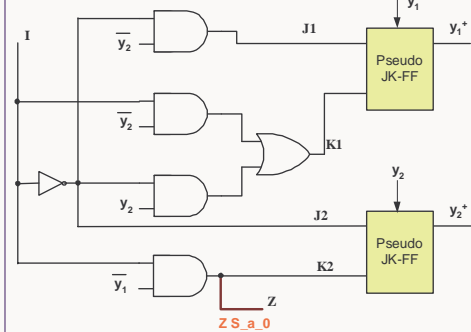
### Example

- Pseudo JK-FF Implements the Function

$y^+ = J y' + K' y$

#### Time Frame 0

- To **Justify y<sub>1</sub><sup>+</sup>=0** → (J<sub>1</sub>K<sub>1</sub>=01) → (p > 0)
- To set J<sub>1</sub>K<sub>1</sub> = 01 → (all options), y<sub>2</sub> Must be Assigned a Value → Needs to be Justified in **YET ANOTHER Time Frame** → (p > 1)



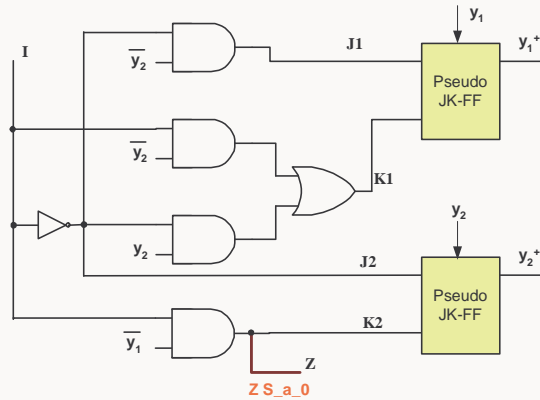
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## Example

### Time Frame -1

- Justify  $y_2^+=1 \rightarrow$   
( $J_2K_2=10$ )  $\rightarrow$  Both  
Satisfied by  $I=0$
- This Represents a  
Self-Initializing Test  
Sequence Since:
  - $\triangleright y_2 y_1 = xx$
  - $\triangleright$  All Lines are Justified
- The Test Sequence  
Becomes:  
 **$I=001$**

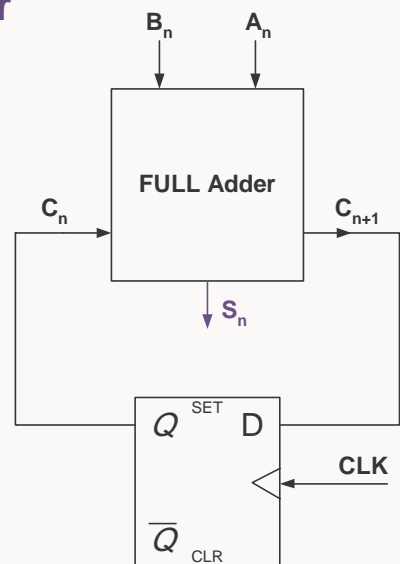


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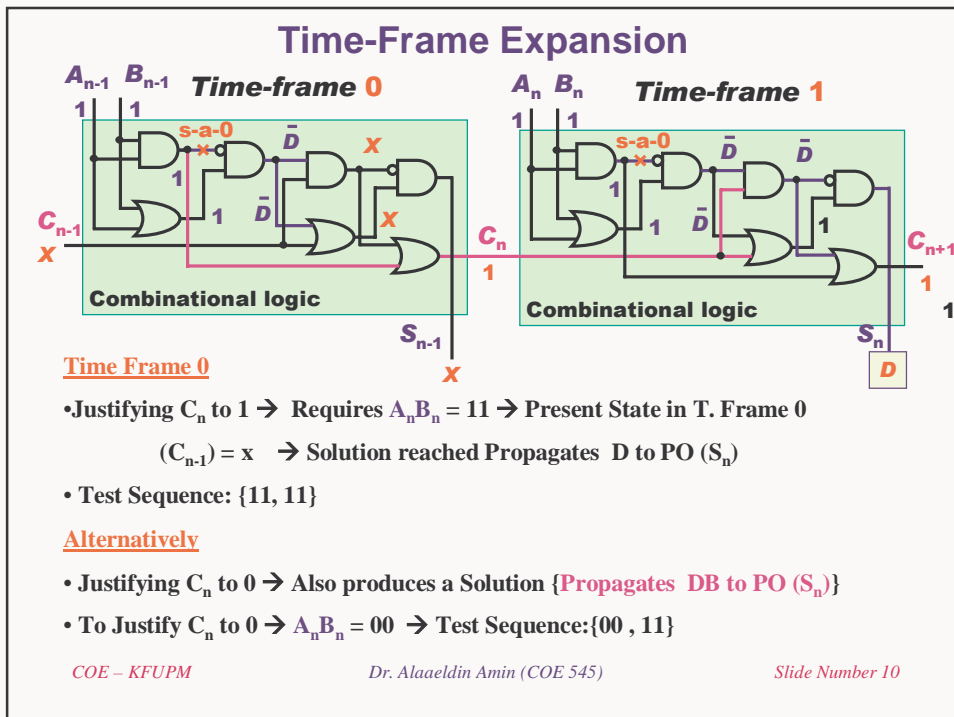
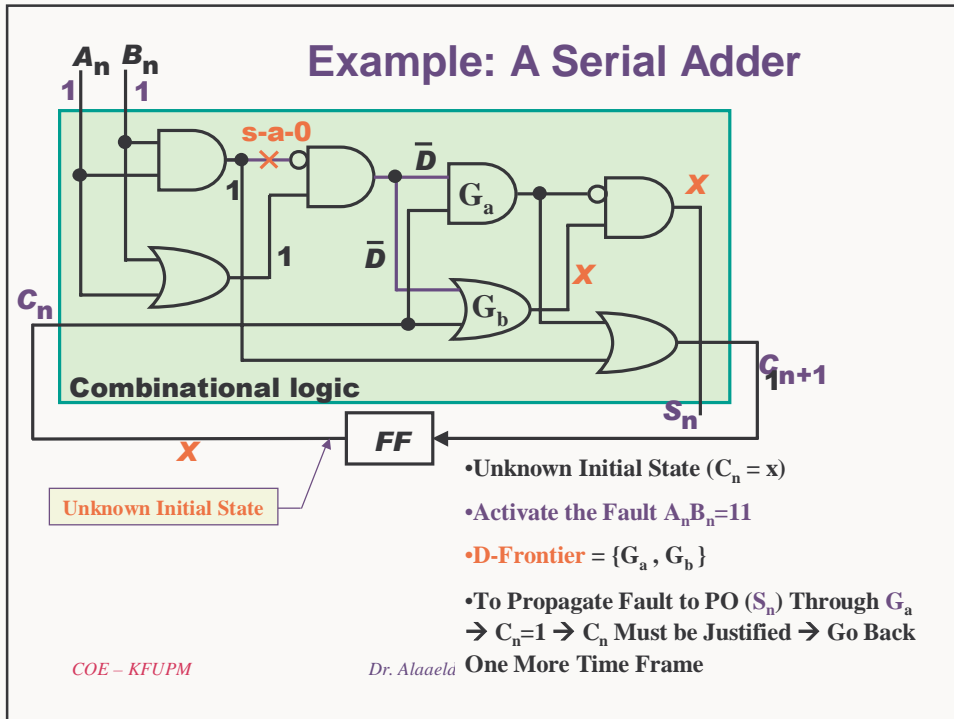
## Example: A Serial Adder



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## 9-Valued Logic

- For Sequential Testing We Need May to Consider All Pairs of {0, 1, X} Signals for the **Good/Faulty** Machines

### Roth's 5-valued algebra:

- **D**            **D'**            **0**            **1**            **X**
- 1/0            0/1            0/0            1/1            X/X

### Muth's 9-valued algebra:

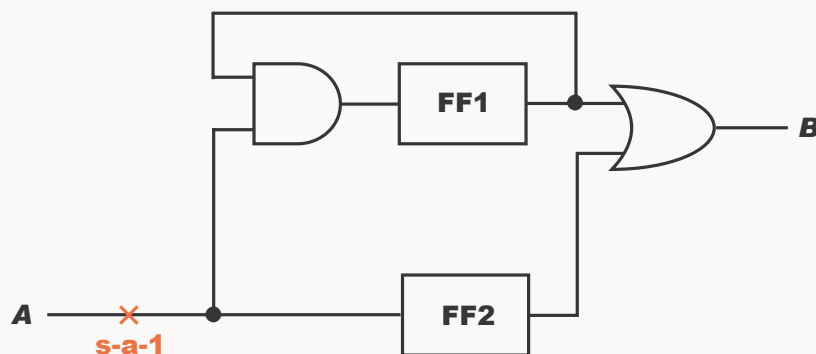
- |          |           |          |          |          |            |            |            |            |
|----------|-----------|----------|----------|----------|------------|------------|------------|------------|
| <b>D</b> | <b>D'</b> | <b>0</b> | <b>1</b> | <b>X</b> |            |            |            |            |
| 1/0      | 0/1       | 0/0      | 1/1      | X/X      | <b>0/X</b> | <b>1/X</b> | <b>X/0</b> | <b>X/1</b> |

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## Example



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