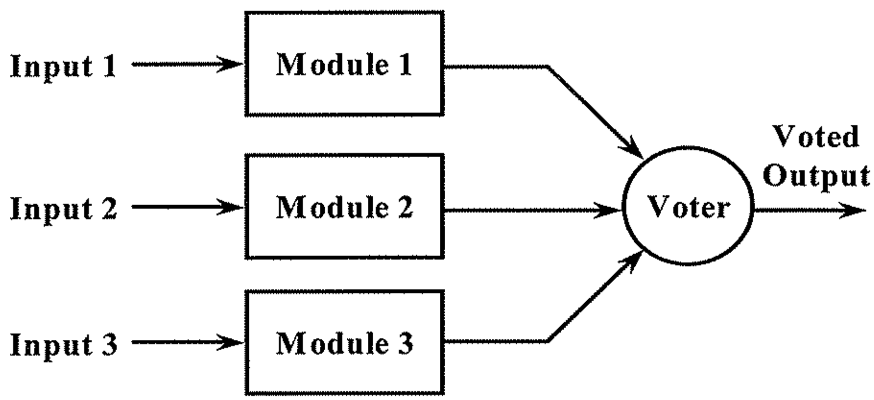
Reliability of TMR



- Reliability of each module: p
- Reliability of the voter: w
- Reliability of TMR?

$$R_{TMR} = \left[C_3^3 p^3 (1-p)^0 + C_3^2 p^2 (1-p)\right] \cdot w$$

$$= \left[p^3 + 3p^2(1-p)\right] w$$

$$= (3p^2 - 2p^3) * w$$

where $C_n^k = \binom{n}{k} = \frac{n!}{k!(n-k)!}$ is binomial coefficient.

Reliability of NMR

- Reliability of each module: *p*
- Reliability of the voter: *w*
- $N = 2n+1$
- Reliability of NMR?

Example: $N=5$

$$R_{5MR} = \left[C_5^3 p^3(1-p)^2 + C_5^4 p^4(1-p) + C_5^5 p^5\right] * w$$

$$= \left(\sum_{i=3}^{5} C_5^i p^i (1-p)^{5-i}\right) * w$$

In general.

$$R = \left(\sum_{i=n+1}^{N} C_N^i p^i (1-p)^{N-i}\right) \cdot w$$

$$C_N^i = \binom{N}{i} = \frac{N!}{i!(N-i)!}$$

Voting Techniques in NMR

- Hardware voting & software voting
- Hardware voting uses a hardware voter
  - Logic gates, using digital logic design technique
- Exercise: design a 1-bit TMR voter that produces an output of 1 when 2 out of 3 inputs are 1
  - Truth table?
  - Karnaugh map?
  - Logic function for the voter?
  - Implementation: circuit?

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Truth Table

(1)

Input A	Input B	Input C	output F
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

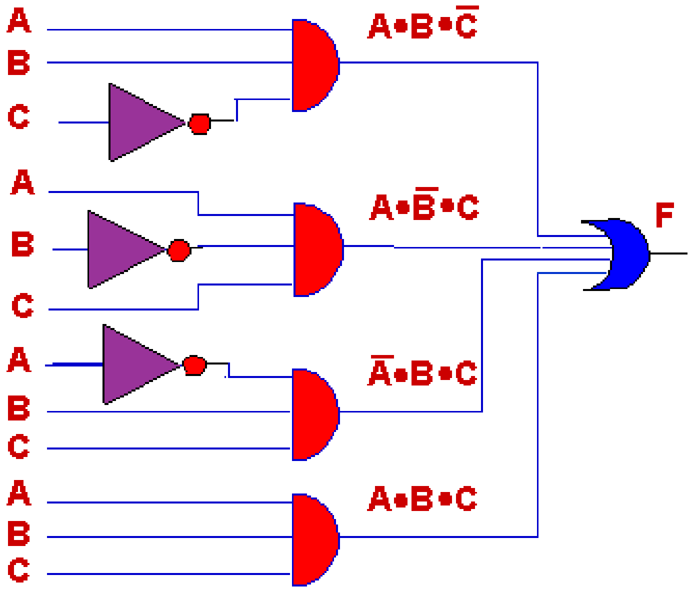
$F = \bar{A} \cdot BC + A\bar{B}C + AB\bar{C} + ABC$ (Top circuit in slide #16)

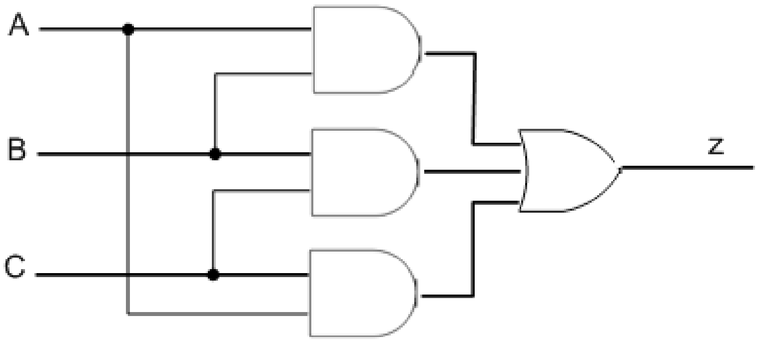
(2) Simplification using K-map

A \ BC	00	01	11	10
0	0	0	1	0
1	0	1	1	1

$F = AB + AC + BC$ (Bottom circuit in slide #16)

Implementation Circuits





An 8-bit or 16-bit majority voter can be constructed using 8 or 16 of the above circuits