TMR System: $R_{sys} = (3R_m^2 - 2R_m^3)R_v$

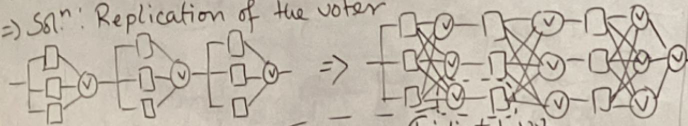
$= 3e^{-2\lambda t} - 2e^{-3\lambda t}$, assuming $R_v = 1$

$MTTF_{TMR} = \int_0^\infty R_{sys}(t)\,dt = (5/6)\cdot 1/\lambda$

K-out-of-n System: $R_{sys} = \left[\sum_{i=k}^{n} \binom{n}{i} R_m^i (1-R_m)^{n-i}\right] R_v$

=) Bottleneck in the design of NMR: Voting ckt [Critical System Core]

=) Soln: Replication of the voter



Triplicated Voter

∴ Total reliability can be considered in place of the module's reliability

=) Another issue with voting: Majority voting is a pessimistic approach. For example, in case of a binary-valued TMR module, if one module fails at stuck-at-1 state and another module fails at stuck-at-0 state, then the only module can provide correct output from the TMR system [Compensating failures].

=) So far discussed: K-out-of-n: G System
↳ for "Good"

→ Needs at least K modules to be functional

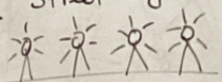
→ Similar to $(n-k+1)$-out-of-n: F System

→ Needs at least $(n-k+1)$ failed modules for sys failure

=) Consecutive K-out-of-n: G System

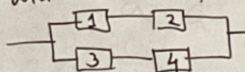
→ Consists of ordered modules, and good condn of at least consecutive k modules keeps the sys funcning

Ex: Street light: ?



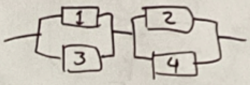
Reliability Block Diagram (RBD)

=) Parallel connn of Series System:

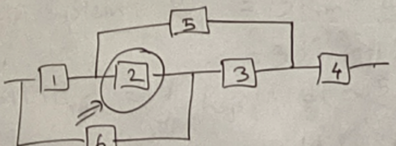


$R_{sys} =$

=) Series connn of parallel System:



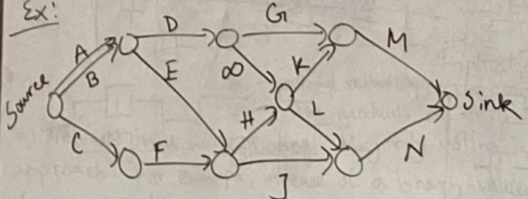
$R_{sys} =$



=) Each module name labels one edge; module failure given disconnected edge.

[An edge labelled with "∞" is never disconnected]

Ex:

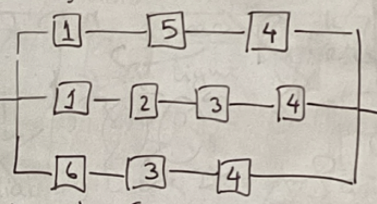


=) Analysis using success paths:

$R_{sys} \leq 1 - \prod_i (1 - R_{i\text{th success path}})$

=) Gives an upper bound on reliability, as it considers paths to be independent

Ex: for the prev. block diagram:



So, $R_{sys} \leq 1 - (1 - R_1R_5R_4) \times (1 - R_1R_2R_3R_4) \times (1 - R_6R_3R_4)$

Reliability Graph:

=) A schematic representation of system components, their interactions, and their roles in proper system operan

=) Use generalized series parallel connns to visualize success paths, which are directed from a source to sink

Fault tree

=) Top-down approach of failure analysis.

=) Start from the top-level failure and then determine all possible ways to that top-level failure

=) Process:

Identify top-level failure =) Identify 1^{st} level contributors to the top-level failure

⇓

Use logical gates to connect 1^{st} level to top

Identify 2^{nd} level contributors ⇐

⇓

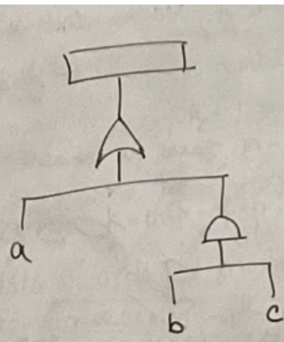
Link 2^{nd} level to 1^{st} level =) Repeat until done

Cut set:

=) A set of initiators: Failures of all these initiators induce the top-level failure

=) Minimal Cut Set: A cut set containing no cut set as its subset.

Ex:



Minimal Cut Set: ?