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Using Fault Tree Technique for inverter Safety System Analysis

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Abstract

Inverter device is a power supply which used widely for different purposes as a (ups) , generating power for houses. It is an important system in our life. As an application, we employ the fault tree analysis approach with logic gates and Boolean algebra operations to determine the causes of failure, for inverter safety systems analysis.

Keywords: Tree technique, Inverter

1.Introduction

(FTA) was invented at Bell Telephone Laboratories in (1962) [2]. However, current fault tree analysis cannot be performed functionally due to imprecise failure input data and modeling issues. As a result, fuzzy sets, invented by L.A. Zadeh thirty years ago, can assist in overcoming this situation. Experts employ fuzzy sets to subjectively explain the uncertainties of any given event failure rate, and then apply mathematical operations to estimate system reliability.. Many papers propose using fuzzy sets to describe the imprecision or ambiguity of events in the real world in fault tree analysis. Zadeh L.A. (1978) [14] investigated a fuzzy set as a foundation for a theory of possibility. Singer D. (1990) [9] presented a method for using a fuzzy set to fault tree and reliability analysis. Tyagi S. K. and et al. (2010) [12] investigated a fuzzy set theoretic approach to fault tree analysis. Using fault tree analysis.Wang Limin (2010) [13] investigated the causes of an oil tank fire and explosion. Huang Y.–L. et al. (2011) [4] proposed modeling dynamic gates and determining the structure function of dynamic fault trees (DFTs). TU, Jiliang; Cheng, Ruofa; and TAO, Qiuxiang (2015)[11] were investigated. Under fuzzy uncertainty, a reliability analysis method for safety-critical avionics systems based on a dynamic fault tree is proposed. Jiang, Ge, et al. (2018)[5] introduced a novel approach to fuzzy dynamic fault tree analysis based on the weakest n-dimensional t-norm arithmetic. Ghadhab, Majdi, and colleagues (2019)[3] conducted safety analysis for vehicle guidance systems with dynamic fault trees. reliability engineering and system safety. Sejin Baek and Gyunyoung Heo. (2021)[1] presented the application of dynamic fault tree analysis to prioritize electric power systems in nuclear power plants. energies. In our paper an analytical study for the safety of inverter using fault tree analysis is presented to determine the events causes the failure (minimal cuts) where an event are subset of outcomes of an experiment.

2.Some definition and concepts:

2.1 In this section we recall some definition and concepts which concern our study

.22 Definition

A fault tree which is abbreviated to (FT) is a logic diagrammatic representation of all its possible events causes the system failure using logical gates.

2.3 Gates and Logic [7],[8]

The OR –gate and the AND –gate are the two most fundamental forms of fault tree gates.

2.3.1 AND – Gate

The AND – gate is used to demonstrate that the output fault occurs only if all of the input faults occur. An AND – gate can have any number of input defects. The fault tree seen in the diagram below represents this

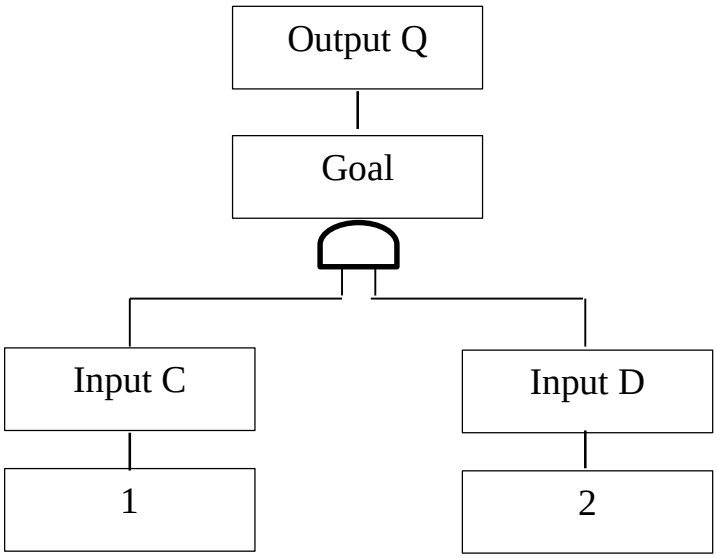

Figure1 :AND-Gate

2.3. 2 OR –Gate

The OR –gate is used to indicate that the output event occurs only if one or more of the input events occur. The fault tree seen in the diagram below represents this .

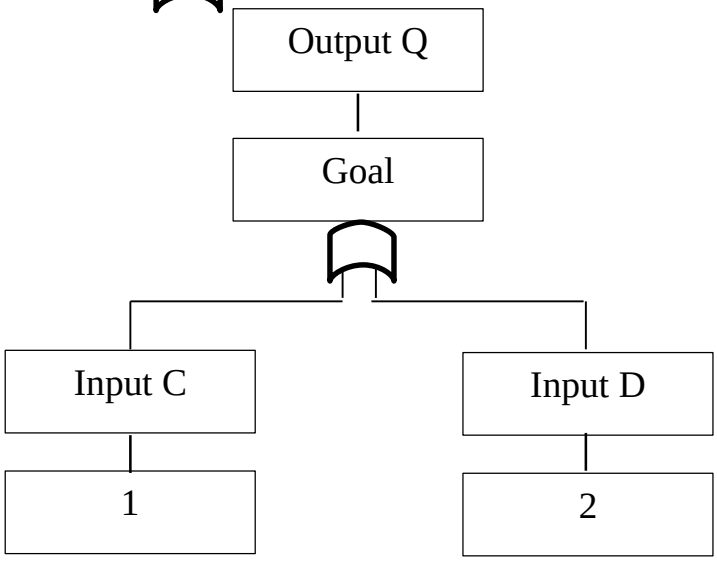

Figure2 : OR-Gate

Note:

The circuit refer to the basic event .

The rectangle refer to the intermediate event which result.

2.4 Definition[6]

The chance that no catastrophic incidents will occur during system operation during a specific time period is referred to as **safety**.

2.5 Definition [10],[7]

Reliability is the likelihood that an object will fulfill its intended function for a certain interval under specified conditions.

2.6 Definition[10] A minimal cut set is a least group of fault tree initiators which if all happen will make the top event happen **.**

3. The Applications

The data for the various components are included in the fault tree (FT) at the lowest hierarchical level and merged together using the logic of (FT) with the Boolean algebra operations to give the failure assessment of the entire system being investigated in quantitative evaluation of fault tree.

The safety system for The fault tree of inverter or (ups) for generating electricity to different uses in our life as shown below . An possible analysis the failure of inverter safety system it depends on different reasons that caused by factors as defect or error in design ,human errors ,failure in safety circuit protection.

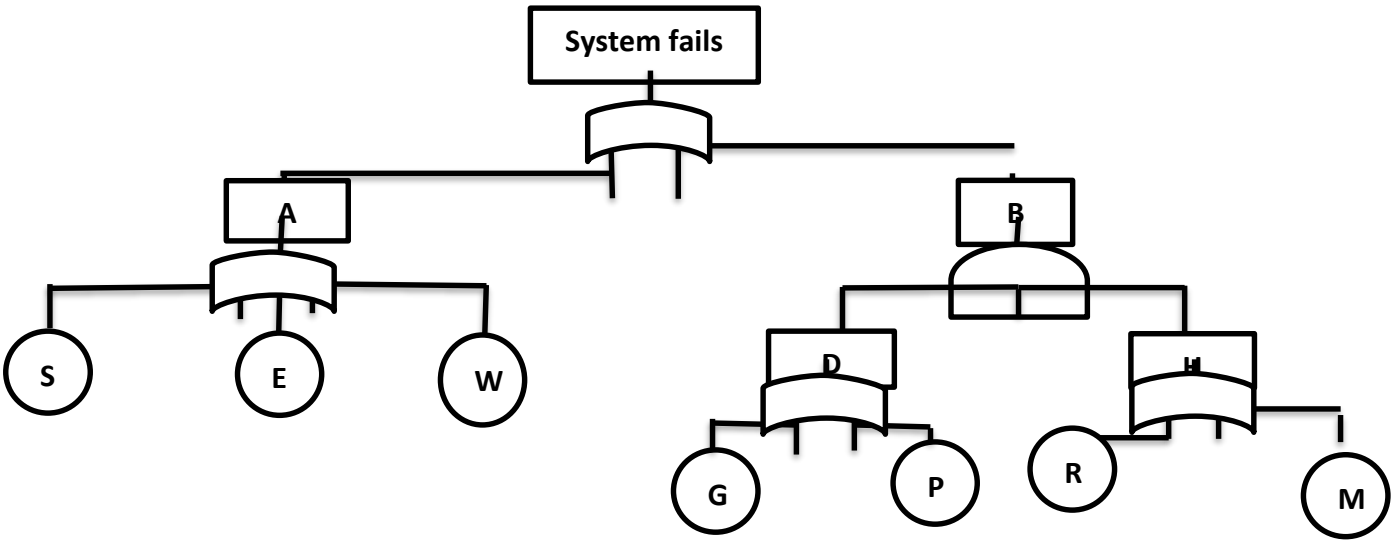

Figure 3: Fault Tree of Inverter Failure

$\boldsymbol{F_{IS}}$ Relate to the inverter system's failure.

$\boldsymbol{F_S}$ Refer to a malfunction in the safety circuit protection device (anti reverse Circuit).

$\boldsymbol{F_W}$ Refer to the failure caused by square wave.

$\boldsymbol{F_G}$ Refer to a design issue created by a nonstandard wire gauge (swg) that is too small, as specified by (swg table).

$\boldsymbol{F_P}$ Is the power efficiency failure caused by a short circuit.

$\boldsymbol{F_R}$ Refers to connection failure induced by human error or misuse (reverse polarity).

$\boldsymbol{F_M}$ Refers to an inverter failure caused by keeping it unmaintained after the battery has run out of power.

$\boldsymbol{F_E}$ Refer to the failure caused by environment factors.

F_{IS} = T = $A \cup B$ where

A = $S \cup W \cup E$, B = $D \cap H$, $D = G \cup P, H = R \cup M$

By substitution T = $(S \cup W \cup E) \cup (D \cap H)$

The detecting safety device failure and inverter system failure are two key factors A and B. Each of them has sub-factors. When the failure of basic events is known, the system failure can be computed. The following is the system failure (Top event) by using Boolean algebra operations.

F_{IS}=$1-(1-F_A)(1-F_B)$ and R_{IS} is :

$R_{IS} = 1 - F_{IS}$

$F_A = F_S + F_W + F_E, F_B = F_D + F_H$

Thus $T = (S \cup W \cup E) \cup [(G \cup P) \cap (R \cup M)]$

$T = (S + W + E) + [(G + P) \times (R + M)]$

$T = (S + W + E) + GR + GM + PR + PM$

The minimal cut sets are (S+W+E),GR,GM,PR, and PM, in that order..

Conclusion:

Because knowledge about the key reasons that cause system failure is sometimes incomplete, (FTA) is a useful method for doing system safety checks. In our work, the possible causes of an inverter system failure are determined through a qualitative analysis

of the fault tree using minimal cut sets obtained from the analysis, which is then shared in troubleshooting for the purpose of assisting engineers and technicians in repair of various equipment.

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