THE CONSTANT FAILURE RATE MODEL FOR FAULT TREE EVALUATION AS A TOOL FOR UNIT PROTECTION RELIABILITY ASSESSMENT

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Introduction

Determining the reliability of unit protection system ia as a serious analytical task. This task is complicated by the fact, that the reliability of Relay Protections (RP) is characteristic, which is not possible to be defined from a "single point of view", nevertheless the fact that under reliability of relay protection is understood the proper protection of the primary power equipment. Generally relay protection reliability can be separated in two aspects:

- Dependability – the relay protection operates correctly in case of in-zone faults. For dependable operation of RP is needed proper action – trip command. The RP is "available" when it is ready to recognize correctly the fault events and give proper command;
- Security - the relay protection must not operate in cases of out - of - zone faults. RP is secure when unexpected trip commands do not occur. When RP gives error trip command there is RP "maloperation".

It is very useful when the logical construction of the models created to make reliability assessment are close to the physical estimated scheme. Another advantage of the method is if it allows the "complex role" of the protection functions/devices to be estimated. For estimating the reliability of unit protection system it is possible to use fault tree analysis method for choosing optimal configuration and set of protection functions.

Purpose

The purpose of this paper is to introduce the fault tree analysis method as a tool for unit protection reliability estimation. The constant failure rate model applies for making reliability assessment, and especially availability assessment. For that purpose is presented an example for unit primary equipment structure and fault tree example for simplified unit protection system.

Unit protection fault tree construction

Example for unit primary equipment structure is given on Figure 1. On the diagram are given some of the main protections for unit structure components.
For the construction of fault trees for the protection scheme the following assumptions were made:

- For simplification the protection devices are assumed to have equal "reliability parameters" (that allows the resulting λ of number of N "connected in parallel" devices to be calculated as λ.N).
- Different protections are connected to separate IT (or separate IT cores).
- Interlocks are not taken in account.
- For the protection system structure given as example, in accordance to the fact that for primary equipment like power transformers, generators and busducts as one of the most important protections are regarded the differential protections, on the given diagrams the other protections are not shown.

- On the unit diagram, and in the fault trees are included the breakers, and the protection functions (Breaker Failure Protection) connected with them.

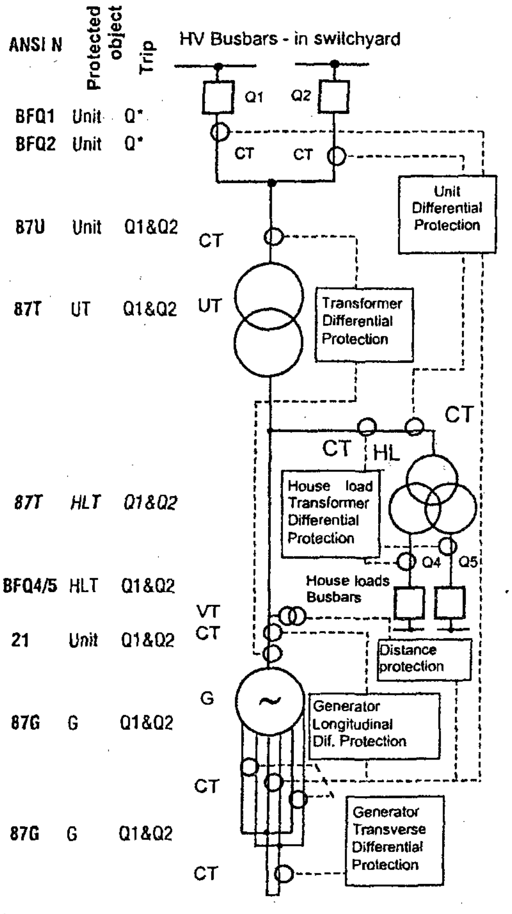
On Figure 2 is given fault tree for the scheme on Figure 1, with the assumption that in the unit is installed one protection system. On Figure 3 is given fault tree for the scheme on Figure 1, with the assumption that there are installed "in parallel" two equal protection systems. The idea of the given as simplified example protection structure is that every component of the primary equipment has it's "own" protection, the whole unit has one redundant protection (unit diff. protection), and there is one protection which covers external and some internal faults (distance protection).

The fault tree can be constructed by different approaches:

- *To estimate the reliability of unit protection "in general".* In this case the parameter N included in the fault trees gives the total number of protection relays concerning unit equipment, excluding the overall redundant protections – in this *example such role have the unit* differential protection and the unit distance protection. In this way can be obtained approximate results for reliability, due to the fact that protection devices have principally different (not covering each other) functions and principles. This approach can be used mostly for availability assessment of the protection system as one complete assembly. The fault trees on Figures 2 and 3 are constructed in this way.

- *To estimate the reliability "in detail".*

In this case the parameter N gives the number of protections concerning certain fault in a particular component of unit structure (For instance phase to phase short circuit in unit transformer). For this purpose different fault trees have to be constructed for different possible faults. In this way a complex result can be obtained to estimate the impact of each protection on the reliability in



Q* - The switchyard breakers are not shown on the figure

Fig. 1 Unit protection structure

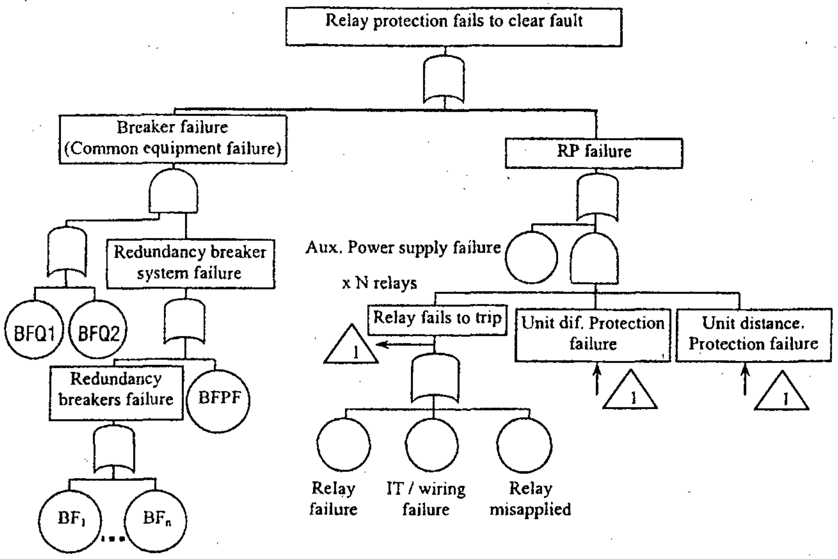


Fig 2. Fault tree for case of one protection system installed on the unit

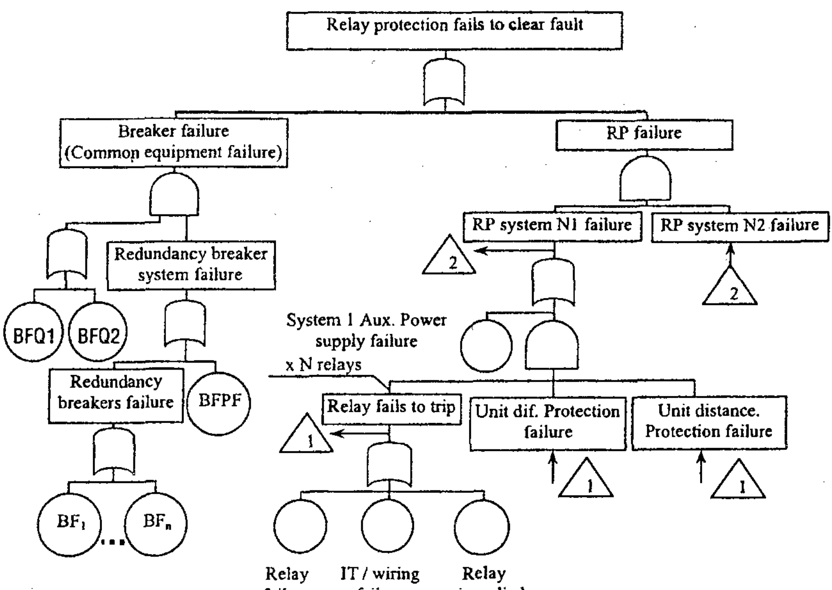


Fig. 3. Fault tree for case of two protection systems installed on the unit

case of certain fault event. It is also possible to form separate fault trees for the faults, which can occur in each component (For instance faults in unit transformer).

Some protection functions of the unit (the main distribution circuit) protection system concern also other parts of the plant electrical power system as the louse load busbars, switchyard and respectively components of the external power system like transmission lines, substations etc. These functions can be qualified as redundant for these components. For that reason a fault tree including some external components and related protections must be modeled to estimate the unit availability as part of the plant structure and part of the power network system.

Conclusions:

1. Fault tree methods are convenient to estimate the availability of systems such as the unit protection. The method of fault tree construction allows forming logical diagram very similar to the physical scheme, which gives convenience, and simplifies the analysis procedures.
2. Practically for detailed reliability analysis must be taken in account the real specifics of the protection devices, the number of IT connected to each protection, etc. For that purpose the fault method can be used to form detailed fault trees with included specific characteristics of the observed devices. For detail analysis the exact value of the λ constant must be taken for each type of protection device.
3. It is possible the results obtained by fault tree analysis to be used for "cost optimization" of alternatives for primary and secondary structures in power plant structures.

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