Analysis of Power Quality Improvement in Voltage Sag and Load Sensitivity Using Fuzzy Logic

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***ABSTRACT*- The power quality (PQ) requirement is one of the most important issues for power companies and their customers. The power quality disturbances are voltage sag, swell, notch, spike and transients etc. The voltage sag is very severe problem for an industrial customer which needs urgent attention for its compensation. There are various methods for the compensation of voltage sag. One of the most popular methods of sag compensation is fuzzy logic technique for PQ disturbance analysis which is used in both low voltage and medium voltage applications. In this paper, the comprehensive reviews of various articles, the advantages and disadvantages of each possible configuration and control techniques pertaining to fuzzy logic are presented. This paper presents a case study application of fuzzy logic in a power quality issue. It describes the computer-based load sensitivity to voltage sags, by using fuzzy sets and IF-THEN inference rules. A fuzzy inference system is experimentally implemented for these cases, showing the general procedures of how to use this theory. It appears that fuzzy set theory can play an important role in diagnosing power quality disturbances. And hence it can offer insights towards the satisfaction of the needs of manufacturers, Utilities and customers.**

***Keywords:* fuzzy sets, power quality, voltage sag, fuzzy expert system, sag, swell.**

I.INTRODUCTION:

The main objective of this research is to explore new possibilities to represent the reliability of computer-based loads, such **as** an electronically controlled equipment, with respect to transient phenomena in electric power systems, Power quality problem is an occur as a non-standard voltage, current and frequency. The power quality has serious economic implications for customers, utilities and electrical equipment manufacturers. Modernization and automation of industry involves increasing use of computers, microprocessors and power electronic systems such as adjustable speed drives .The power electronic systems also contribute to power quality problem (generated harmonics). The electronic devices are very sensitive to disturbances and become less tolerant to power quality problems such as voltage sags, swells and harmonics. Due to the harmonics are occurring in the system it causes losses and heating of motor Power quality is among the main things that is emphasized and is taken into consideration by utilities in order to meet the demands of their customer. At each passing day this issue has becoming more serious and at the same time the user's demand on power quality also gets more critical. Thus it is essential to establish a power quality monitoring system to detect power quality disturbance such as voltage sags. Several research studies regarding the power quality have been done before and their aims frequently concentrated on the collection of raw data for a further analysis, so their impacts of various disturbances can be investigated. To obtain unique features of the voltage disturbances, fast Fourier transform analysis and root mean square averaging technique are utilized so as to determine the disturbances parameters such as duration, maximum and minimum rms voltage magnitudes. Based on these parameters, a fuzzy expert system has been developed to set the fuzzy rules incorporating five inputs and three outputs. The power quality disturbances have been organised into seven categories based on wave shape.

Fuzzy logic has become the most successful and latest technologies for developing sophisticated control system [5]. It is a powerful variation of crisp logic based on the experience and knowledge of human being. In these applications fuzzy expert system has been developed to classify short duration voltage disturbances. That is why FL expert system is developed with five inputs, three outputs and 139 rules. The FL logic inputs consider the maximum and minimum voltage magnitudes in per unit and the disturbance duration in seconds.

II.TECHNIQUES

***ARTIFICIAL INTELLIGENCE*: Artificial intelligence** emerged as a computer science discipline in the mid 1950s. Since then it has produced a number of powerful tools, many of which are of practical use in engineering to solve difficult problems normally requiring human intelligence. These tools are fuzzy logic neural networks and genetic algorithms.

***FUZZY LOGIC*-Fuzzy logic** is a form of many-valued logic; it deals with reasoning that is approximate rather than fixed and exact. Compared to traditional binary sets (where variables may take on true or false values) fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false.[1] Furthermore, when linguistic variables are used, these degrees may be managed by specific functions. Irrationality can be described in terms of what is known as the fuzzy objective. The term "fuzzy logic" was introduced with the 1965 proposal of fuzzy set theory by Lotfi A. Zadeh. Fuzzy logic has been applied to many fields, from control theory to artificial intelligence. Fuzzy logics however had been studied since the 1920s as infinite-valued logics notably by Łukasiewicz and Tarski. It provides both an intuitive method for describing systems in human term.

IF-THEN logic rules can be used to combine membership values for fuzzy variables, trying to mimic the human reasoning process. **All** the consequences for each defined rule are aggregated to give the result that is expected to be a real value, which is supposed to be the closest to the real knowledge being modelled. When fuzzy set theory is used to solve real problems, the following steps are generally followed [6].

1) Description of the original problem in a linguistic or mathematical form.
2) Definition of the input and output variable for the fuzzy inference system, whose range and thresholds can be based on empirical knowledge;
3) Appropriate definition of the number and shape of membership functions for each input and output variables. The membership functions express the degree of satisfaction of a certain variable value into a defined fuzzy set.
4) Definition of **IF-THEN** inference rules, that must represent the system practical behaviour being modelled by a human being.

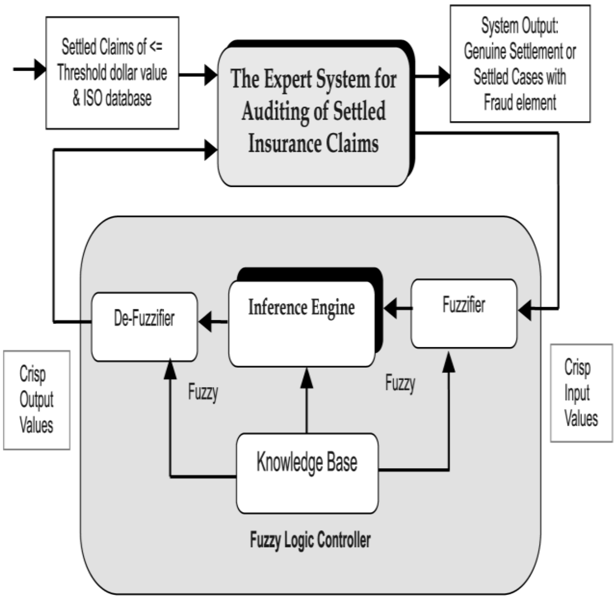

Fig 1: Fuzzy expert system

5) Selection of the fuzzy operators for the defuzzification process in order to assure that the results obtained are similar to those observed in the real world.
6) Tuning the fuzzy inference system by feedback to the previous steps.

III. FORMULATION OF THE LOAD VOLTAGE SENSITIVITY CASE STUDY BASED ON FUZZY SETS Because most of the power quality problems are related to voltage sags, for this project only this type of voltage variation will be considered for modelling the load sensitivity. Four trapezoidal membership functions are defined for each of the input variables as shown in Table: 1

Membership function	Input 1 Voltage	Input 2 Time duration	Output1 reliability
1	Extremely low	Extremely short	failure
2	Very short	Very short	Almost failure
3	Long	short	average
4	normal	long	Almost success
5			success

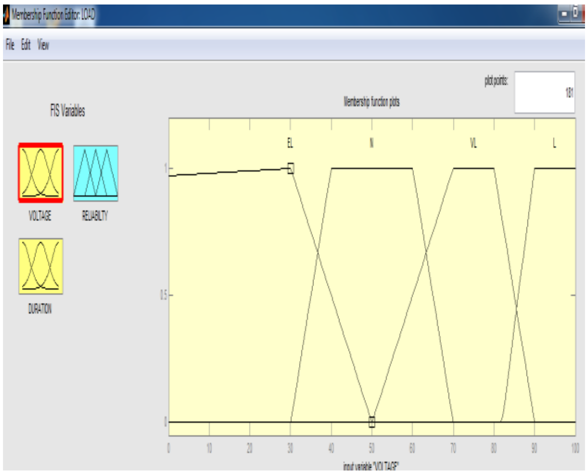

Fig: 2 Input voltage magnitude membership functions

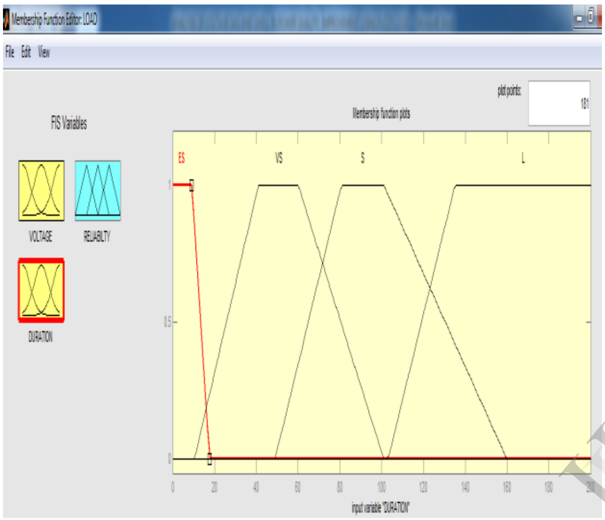

Fig: 3 Time duration input membership function

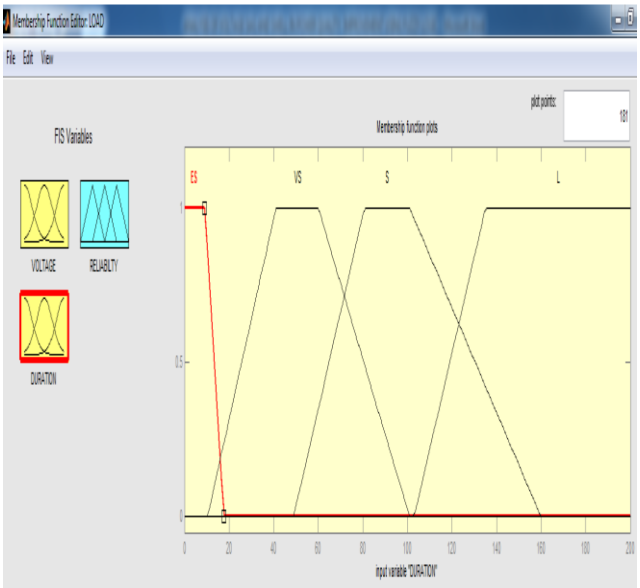

Fig: 4 Reliability output membership function

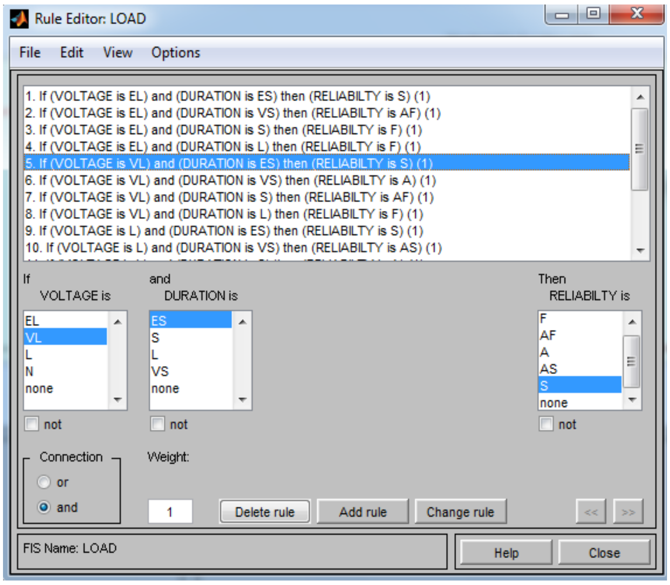

Fig: 5 Inference rules for voltage variation

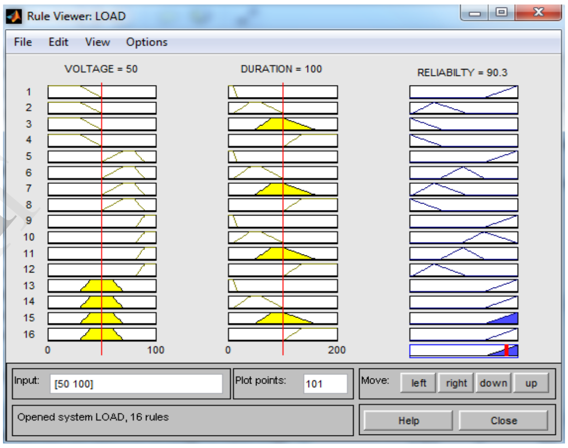

Fig: 6 Process of fuzzy inference

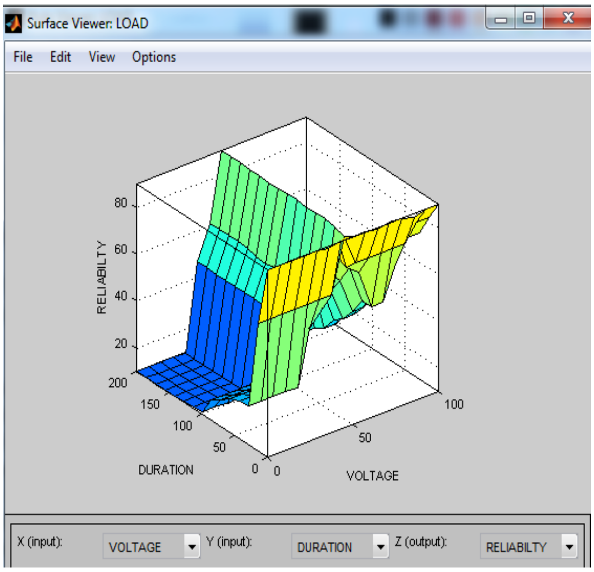

Fig: 6 3D surface view of voltage variation with load sensitivity

IV.Analysis Of Voltage Variation And Time Duration With Reliability

S. No	Input Voltage	Time Duration	Reliability
1	12.4	62.7	23.5
2	15	75.5	20.7
3	18.8	82.7	19.5
4	26.6	88.2	18.1
5	28.9	97.3	13.3
6	35.3	77.3	41.6
7	39.9	82.7	50.6
8	44.5	86.4	59.5
9	48.2	91.8	75.1
10	50	101	90.3
11	54.6	108	63.1
12	59.2	121	48.8
13	65.6	126	39.7
14	70.2	68.2	37.1
15	70.2	128	20.6
16	79.4	139	18.6
17	82.1	152	15.9
18	87.6	37.3	67.2
19	87.6	161	25.1
20	93.1	168	26.3
21	13.3	168	9.96
22	16.1	148	9.96

V.CONCLUSION

This paper has presented a case study application of fuzzy logic to a power quality issue. It describes the computer based load sensitivity to voltage sags, by using fuzzy sets and IF-THEN inference rule. This type of sensitive load has an inherent uncertainty, i.e., power quality tolerance varies according to differences in equipment manufacturers, device application, and so on. The results presented show the potential of intelligent system techniques for diagnosing power quality disturbances, giving answers to the needs of manufacturers, utilities, and electric energy customers.

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