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Characterization of Voltage Dips Due To Faults

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***Abstract*—** An electrical power system is expected to deliver undistorted sinusoidal rated voltage continuously at rated frequency to the end users. A PQ problem can be defined as "any problem manifested in voltage, current, or frequency deviations that results in failure or mal-operation of utility or end user equipment."[12]. Voltage Dip (Sag) is a power quality problem that is prevalent in any power system. It is said to be one of the main problems of power quality. The main causes of voltage dip are due to faults and large rating induction motor starting. Modern power electronic equipment is sensitive to voltage variation and it is also the source of disturbances for other customers. This increased sensitivity of the equipments to voltage dips has highlighted the importance of quality of power, the electric utilities and customers have become much more concerned about the quality of electric power service.

Keywords— Induction Motor, Voltage dip, Artificial neural network, wavelet transform

1. INTRODUCTION

Over the last ten years, voltage dips have become one of the main topics concerning power quality among utilities, customers and equipment manufacturers. Voltage dip is short duration reduction in rms voltage. Typical causes for generation of voltage dips are short circuit faults, switching operations and starting of large rating induction motors.

Voltage dips occur during faults in a wide part of the power system. Disruptive voltage dips are mainly caused by short-circuit faults. Voltage dip can occur due to short circuit fault located hundreds of kilometers away from the affected area. This makes it much more complicated than other power quality problems.

Voltage dip can cause induction motors which constitute a large portion of the loads in industrial power systems to trip by protection relays to protect the motor from any possible damage.

The large interest in voltage dip is due to the problems they cause on several types of equipment. Especially computers, adjustable-speed drives and process-control equipment are notorious for their sensitivity.

2. BACKGROUND

A. Voltage Dip Classification

The voltage sag as defined by IEEE, Standard 1159-1995, and IEEE Recommended Practice for Monitoring Electric Power Quality is a decrease in root mean square (RMS) voltage at the power frequency for durations from 0.5cycles to 1 minute. The magnitude of voltage sag lies between the 90% to 10% of nominal voltage.

Momentary voltage sag is defined as the decrease in RMS voltage at a power frequency for duration from 0.5 cycles to 3 seconds. Temporary voltage sag is defined as the decrease in RMS voltage at a power frequency for duration from 3 seconds to 1 minute.

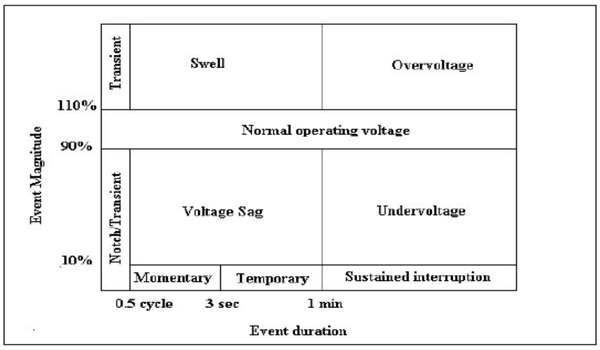

Fig. 1. Voltage Magnitude Events as used in IEEE Std. 1159-1995

B. Voltage Dip Characteristics

1. Magnitude
2. Duration
3. Phase Angle Jump

3. SYSTEM UNDER STUDY

Fig.2 shows modified IEEE distribution test feeder. The system data is given in circuit parameters. The objective is to discriminate the voltage dips due to faults in a power system. This information may be used to take proper countermeasures to maintain the bus voltage during system faults within specified limits.

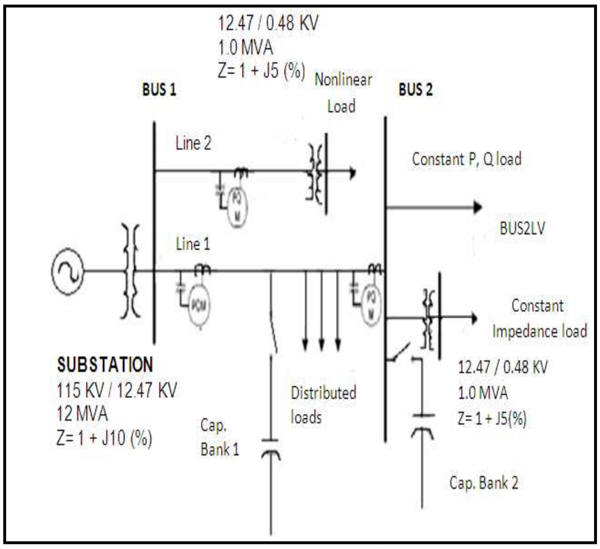

Fig.2: The modified IEEE distribution test feeder

Single line diagram of the system simulated in PSCAD software

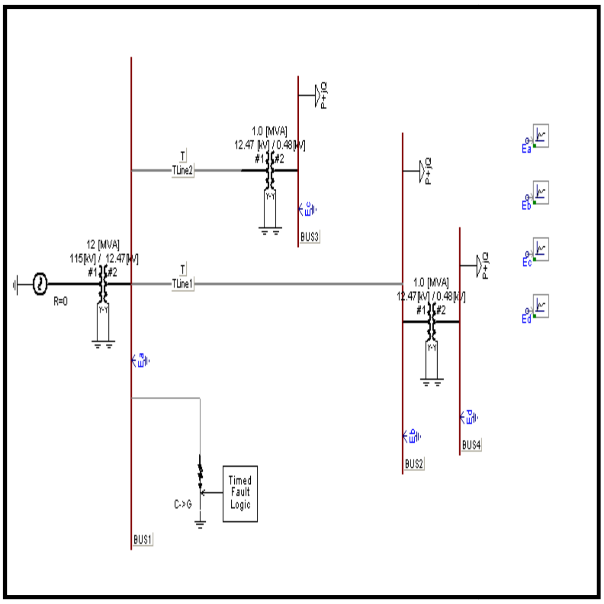

Fig. 3: Single-line diagram of the system simulated in PSCAD Software for LG fault

The voltage waveform on 4 buses are plotted but the study has been conducted on bus 1 and presents the results obtained particularly for voltage dips due to different faults. At bus 1 voltmeter E_a is connected for measuring the bus voltage. The other buses i.e. bus no.2, bus no.3 and bus no.4 are also affected.

The voltage dips are observed in the system voltage due to the creation of different faults like LG, LL, LLG, LLL, and LLLG. The faults are created in the circuit by using timed fault logic for specifying the instant of fault and the duration. The sampling frequency to extract the data is 10 KHz.

The signals obtained from PSCAD are further analyzed using wavelet transform. The wavelet transform decomposed the signal up to six decomposition levels by using Daubachies Db4 wavelet. The decomposition gives approximations and detailed coefficients. The detailed coefficients at level 4 obtained from DWT are further subjected to various statistical parameters for increasing the detection accuracy.

Then these extracted features are provided as an input to ANN for classification of voltage dips due to faults.

4. RESULTS AND DISSCUSSIONS

Time domain approach

Voltage dips due to faults

The voltage dips is observed in the system voltage due to the creation of different faults like LG, LL, LLG, LLL and LLLG. The faults are created in the circuit by using timed fault logic for specifying the instant of fault and the duration. The study has been conducted on bus no.1. At bus 1 voltmeter E_a is connected for measuring the bus voltage. It has been observed that the voltage dip occurs between the time a fault initiates. It can be seen from the simulated waveform, the magnitude of voltage at bus no.1 is reduced i.e. voltage dip is obtained. The voltage dip remains same till recovery of fault. After recovery of fault, normal value of voltage is obtained. The other buses i.e. bus no.2, bus no.3 and bus no.4 are also affected.

[A] LG fault

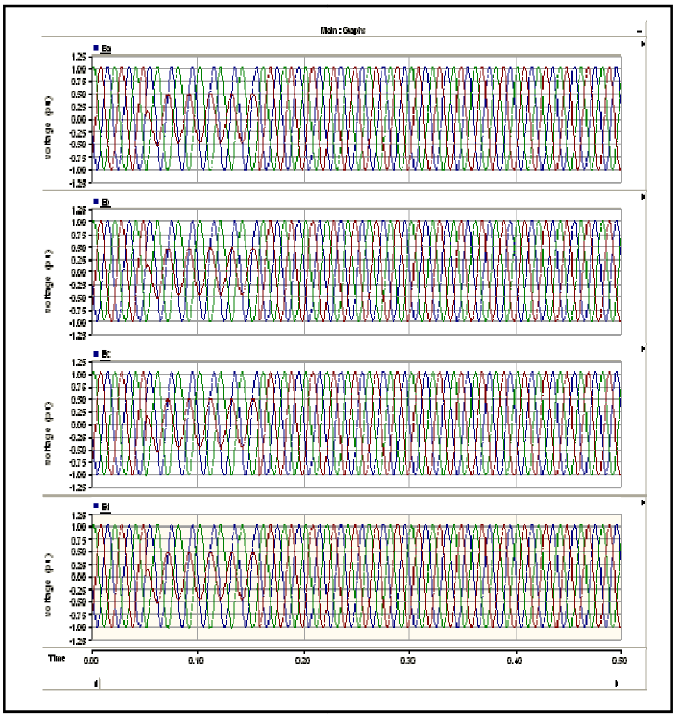

Fig.4: Voltage dip due to LG fault (simulation)

From fig.4 shows waveforms for voltage dip due to LG fault. In this case fault is created in phase c to ground. It has been observed there is dip in only one phase i.e. (in phase c). It can be seen from the simulated waveform, the magnitude of voltage is reduced i.e. voltage dip is obtained.

[B] LL fault

From fig.5, it has been observed there is dip in two phases i.e. phase B and phase C. Due to LL fault, the magnitudes of the voltages of the three phases are unequal. After recovery of fault, normal value of voltage is obtained.

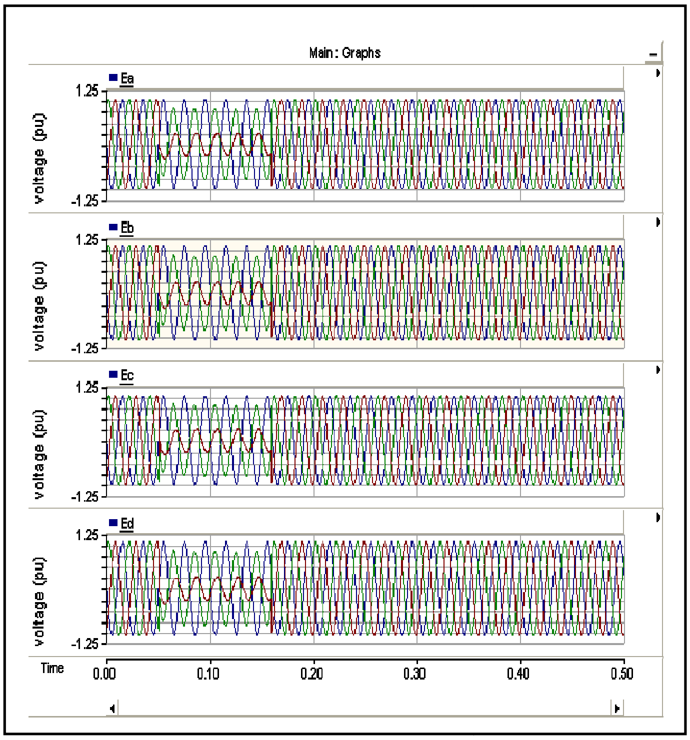

Fig.5 : Voltage dip due to LL fault (simulation)

[C] LLG fault

In this case fault is created in phase A and C along with the ground. From fig.6, it has been observed there is dip in two phase and magnitude of voltage magnitude is reduced i.e. voltage dip is obtained.

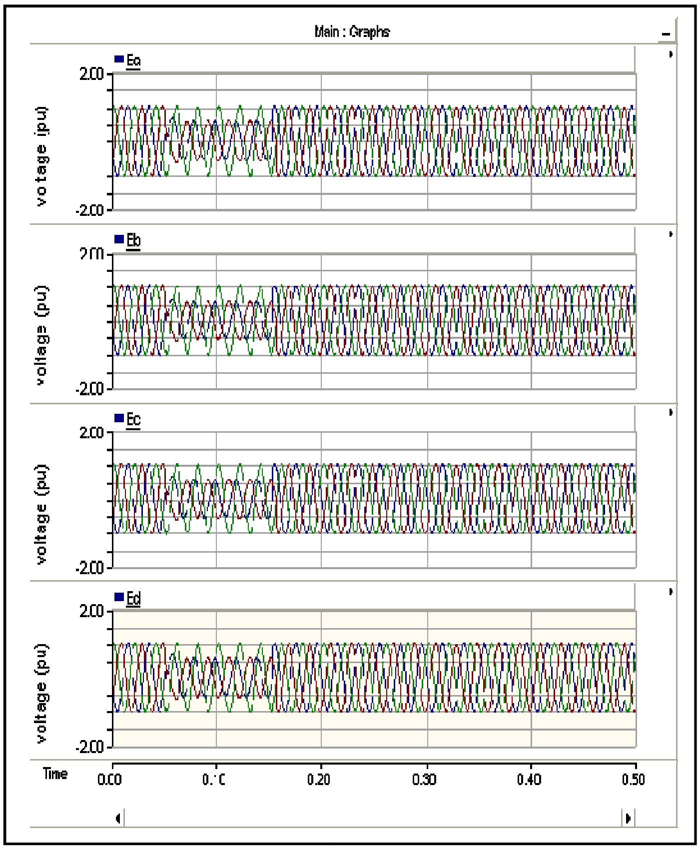

Fig.6: Voltage dip due to LLG fault (simulation)

[D] LLL fault

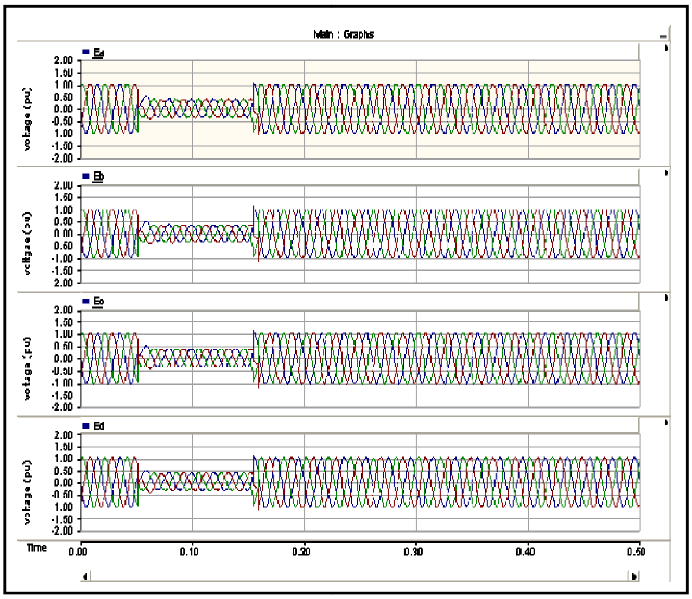

Fig.7: Voltage dip due to LLL fault (simulation)

The LLL fault is created in all the three phases A, B and C respectively. It has been observed there is dip in three phase and magnitude of voltage is reduced i.e. voltage dip obtained.

[E] LLLG fault

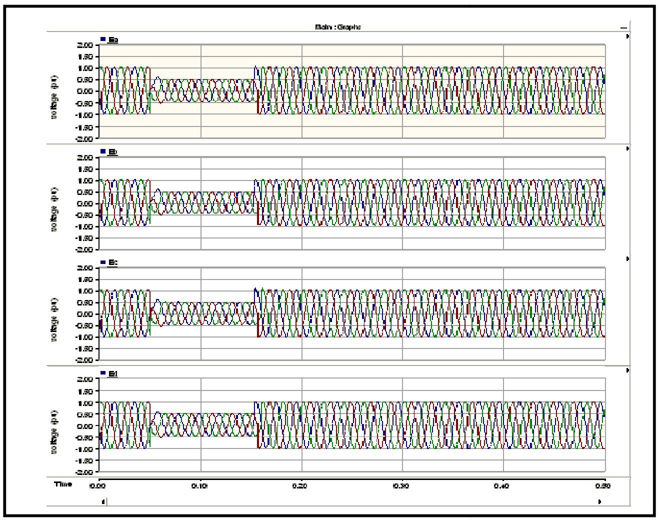

Fig.8: Voltage dip due to LLLG fault (simulation)

A voltage dip due to LLLG fault as shown in fig. 8.It has been observed there is dip in three phases A, B and C along with the ground. The magnitude of voltage is reduced i.e. voltage dip obtained.

Wavelet transform approach

The signals obtained from PSCAD are further analyzed using wavelet transform. The wavelet transform decomposed the signal up to six decomposition levels using db4 wavelet. The decomposition gives approximations and detailed coefficients.

The decomposed signal for voltage dips are due to different faults like LG, LL, LLG, LLL, LLLG are as shown below.

[1] Wavelet decomposition of signal for voltage dips due to LG faults

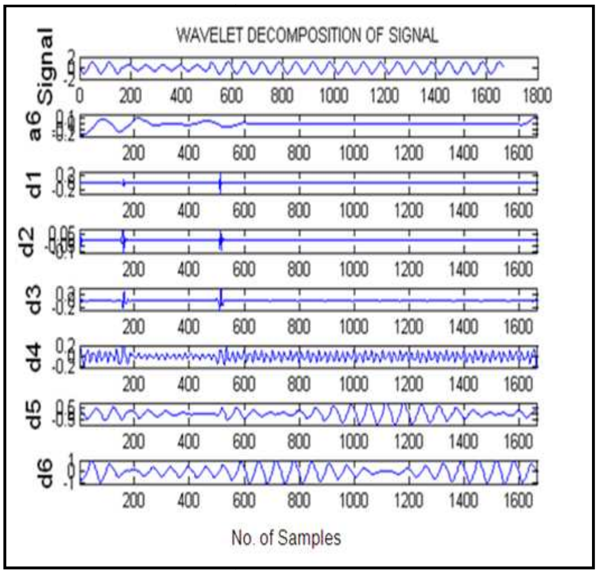

Fig.9: Wavelet decomposition of signal of voltage dip due to LG fault

Fig.9. shows the original signal and wavelet decomposition of waveforms of voltage signal up to sixth level of LG fault i.e. (phase c to ground fault). The original signal shows the voltage dip due to LG fault. The effect of LG fault can be more clearly visualized in D4 level.

Statistical parameters approach (simulation)

The detailed coefficient at level 4 obtained from DWT is further subjected to various statistical parameters for increasingthedetectionaccuracy.

The statistical parameter such as max. value, std. deviation, variance, skewness, kurtosis and energy are calculated with the help of MATLAB programming.

1. When 6 parameters(max. value, std. deviation, variance, skewness, kurtosis, and energy) are given as input to Generalized feed forward neural network.

Table 1 - The variation in correct classification with respect to number of processing element for 6 parameters using GFNN (Simulation).

No. of PE	LG%	LL%	LLG%	LLL%	LLLG%
1	0	100	100	100	100
2	0	100	100	100	33.33
3	0	100	100	100	100
4	100	100	100	100	100

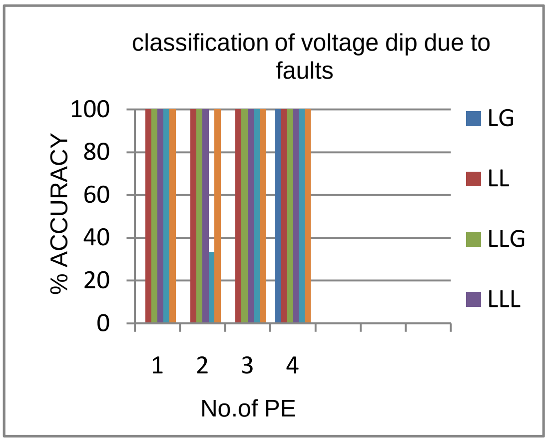

Fig.10: Effect of number of processing element on classification accuracy for 6 parameters using GFNN.

The fig.10, indicates that when number of processing element are taken as 4, then 100% accuracy is obtained. The voltage dip classification is performed for faults like LG, LL, LLG, LLL, LLLG.

Table 2 - The variation in correct classification with respect to number of processing element for energy parameter by using GFNN (Simulation).

No. of PE	LG%	LL%	LLG %	LLL%	LLLG%
1	100	100	50	66.66	75
2	100	100	50	66.66	75
3	100	100	50	66.66	75
4	100	50	50	66.66	100
5	100	100	50	66.66	100
6	100	100	50	66.66	100
7	100	100	50	66.66	100
8	100	100	50	66.66	100
9	100	100	0	66.66	100
10	100	100	0	66.66	100
11	100	100	0	66.66	100
12	100	100	0	66.66	100
13	100	100	50	66.66	100
14	100	100	100	66.66	100

5. CONCLUSION

In this paper the modified IEEE distribution test feeder System is simulated in PSCAD. The data obtained from simulation is in time domain. With the help of magnitude of voltage and duration of events, the cause of voltage dips cannot discriminate properly. Hence in order to obtain correct classification the Wavelet approach is used.

By using Generalized feed forward neural network (GFNN) for six parameters such as maximum value, standard deviation, variance, skewness, kurtosis and energy gives 100% results by simulation analysis i.e. 100% classification of voltage dips due to various types of faults.

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