Asian Journal of Information Technology 5 (11): 1206-1209, 2006

New Algorithm for Detection and Localization of Single Phasing Faults in AC Power Supply and AC Load

Tarak Benslimane
University of Boumerdes, Algeria

Abstract: In this study is presented a new algorithm based on logical functions to detect open phase fault in its two cases (open phase fault point before and after voltage sensor) in AC currents electrical power networks. This algorithm is based on RMS and phase angles values of three phases voltages and currents as input values of detection system that is basically based on logical functions. This system is applied on three phase electrical power network of sinusoidal voltage. It can also be applied on PWM voltage that must be filtered to get its fundamental RMS value. Simulation program was developed in Matlab/Simulink/PLECS software. Simulation results are presented.

Key words: Open phase, Three phase system, sinusoidal voltage, sinusoidal currents, RMS value, phase angle, logic functions, boolean value

INTRODUCTION

Although utilities aim to improve quality and reliability of their systems, due to the inherent nature of power systems, voltage disturbances and power fluctuations cannot be fully prevented[1,2]. AC systems (AC network, induction motor) may be exposed to many kinds of fault (over-voltages, under-voltages, unbalanced-voltages, voltage sags, open phase fault, …etc). Open phase faults, also called single phasing fault, is one of the common faults in electrical power supply systems.

Voltage and current sensors are used to provide informations about the electrical system in different states of safe and fault cases. Open phases fault point may be located after the voltage sensor (in the load side of system) or before the voltage sensor (in the power supply side of system) Fig. 1. It is important to detect and locate the open phase fault to take the necessary procedures in each case.

Many works have been done in electrical systems faults detection basing on many classification strategies. These works covered different cases of voltages and currents faults. Classification of open phase fault according to its happening point location (electrical power supply side or load side) is scarcely studied.

In this study, a new classification technique of open phase fault according to its happening point locations is proposed. This technique is based on RMS and phase angles values of three phases voltages and currents as input values of detection system that is basically based on logical functions. This method is a simple and practical one.

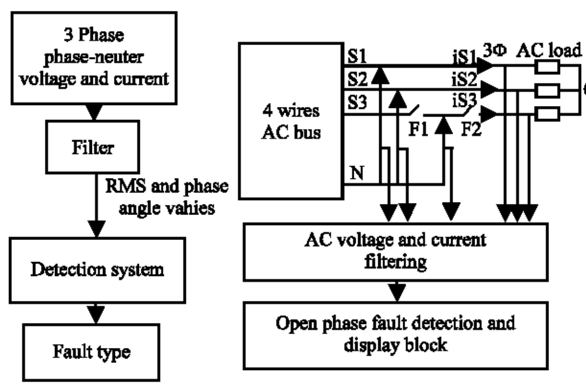

Fig. 1: Schematic diagram of open phase fault (phase 3) detection in AC system (open phase fault point before and after voltage sensor)

OPEN PHASE FAULTS DETECTION SYSTEM

AC systems diagnosis scheme is presented in Fig. 1. Phase3 Open phase fault where the cut point is located after the voltage sensor is simulated by closing F1 and opening F2 and when the cut point is located before the voltage sensor F1 is open and F2 is closed.

In the following part, we simulated the two kinds of open phase faults and their corresponding voltage and currents RMS values as well as phase angles variations provided by voltage and current sensors. Three phases system voltages and currents in open phase fault condition (Phase 3 is in open fault) are presented in Fig. 2.

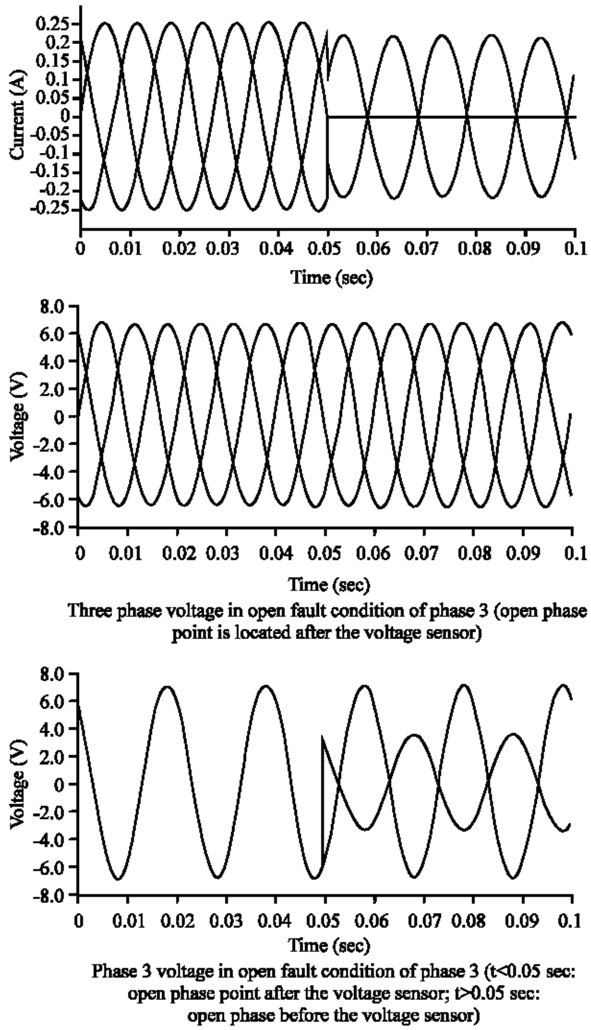

Fig. 2: Phases voltages currents in open phase fault (phase 3 open phase fault point before and after the voltage sensor)

The simulation was done by using the software programmation Matlab/Simulink and Labview with following parameters:

Vrms = 47 V (safe operating condition), 50 Hz for Matlab/Simulink simulation.

This algorithm of faults detection is applied on three phase balanced resistive load (R1 = R2 = R3 = 270 Ohm). From Fig. 2 it is remarked that:

- In both kinds of open phase faults, the phase current of the faulty phase is nil (is 3 = 0A) and the other phases currents are in opposite phase angles ($\Delta\varphi = \varphi_{is1} - \varphi_{is2} = 180°$).
- When the cut point is located after the voltage sensor this former outputs the third phase-neuter voltage of power supply that is similar to that in no open phase fault ($v_{sensor3} = v_{S3N}$; Vrms1 = Vrms2 = Vrms3).

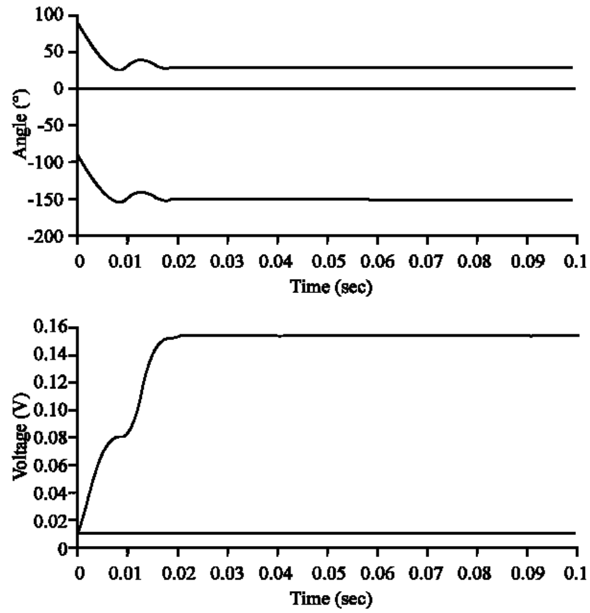

Fig. 3: Phases currents phase angles and rms values in open phase fault (phase 3 open phase fault point after the voltage sensor)

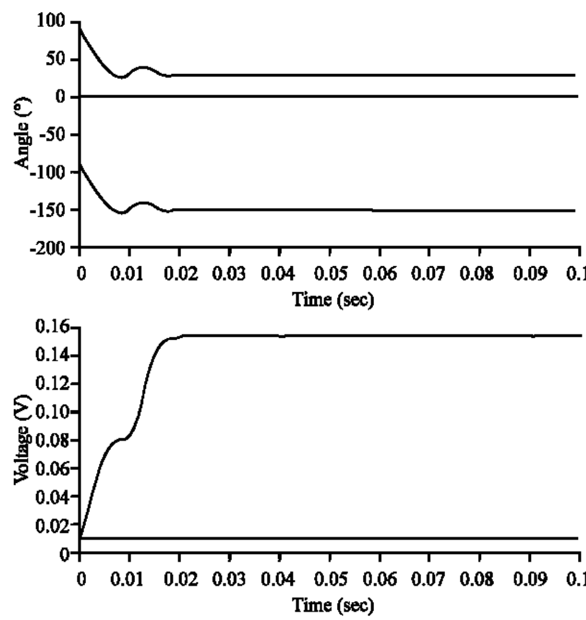

Fig. 4: Phases currents phase angles and rms values in open phase fault (phase 3 open phase fault point before the voltage sensor)

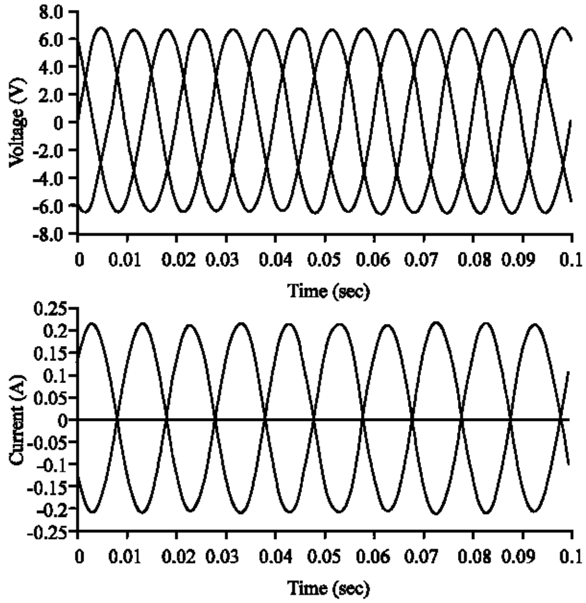

Fig. 5: Phases voltages and currents in open phase fault (phase 3 open phase fault point after the voltage sensor)

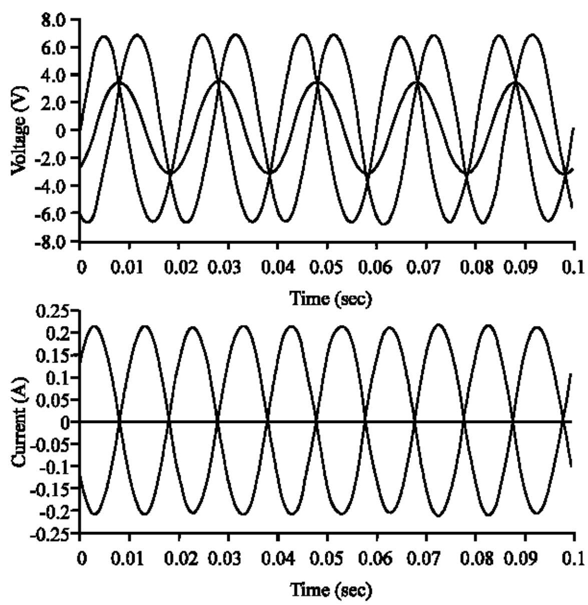

Fig. 6: Phases voltages and currents in open phase fault (phase 3 open phase fault point before the voltage sensor)

- When the cut point is located before the voltage sensor this former outputs the artificial load neuter-power supply neuter voltage that is different in rms value and in phase angle value to that in which cut point is located after the voltage sensor ($v_{sensor3} = v_{ON}$; Vrms1 = Vrms2 = Vrms3).

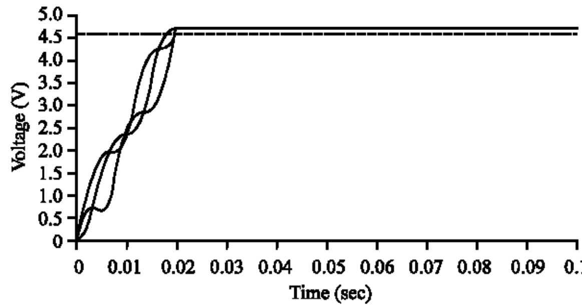

Fig. 7: Phases voltages rms values in open phase fault with the minimum rms value reference of 46 V (phase 3 open phase fault point after the voltage sensor)

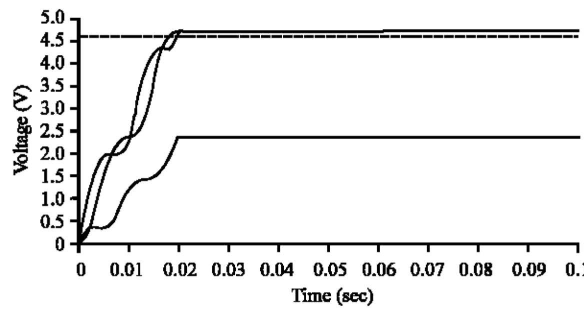

Fig. 8: Phases voltages rms values in open phase fault with the minimum rms value reference of 46 V (phase 3 open phase fault point before the voltage sensor)

Basing on these characteristics, the two cases of open phase fault detection algorithm is made. In this algorithm we fixed a minimum rms value reference for phases currents ($i_{rms\ min\ ref} = 0.25$ A) as well as $\Delta\varphi$ band reference for phases currents phase angles that are safe ($\Delta\varphi = 180\pm5°$).

The case of open phase fault condition is considered if one of the phase currents rms values is inferior then $i_{rms\ min\ ref}$ ($i_{s1rms} < I_{rms\ min\ ref}$ or $i_{s2rms} < I_{rms\ min\ ref}$ or $i_{s2rms} < I_{rms\ min\ ref}$) <u>or</u> one of the phase currents phases angles differences belongs to $\Delta\varphi_{band}$ ($|\Delta\varphi is_{12}| \in \Delta\varphi_{band}$ or $|\Delta\varphi is_{23}| \in \Delta\varphi_{band}$ or $|\Delta\varphi is_{31}| \in \Delta\varphi_{band}$) Fig. 3 and 4.

To distinguish which case of open fault, before or after voltage sensor, is happening, the rms values of phases voltage is based. If the open phase voltage point is located after the voltage sensor in the faulty phase Fig. 5, this former is outputting the third phase-neuter voltage of power supply that is similar to that in no open phase fault ($v_{sensor3} = v_{S3N}$; Vrms1 = Vrms2 = Vrms3). If the cut point is located before the voltage sensor this Fig. 6 former outputs the artificial load neuter-power supply neuter voltage that is different in rms value and in

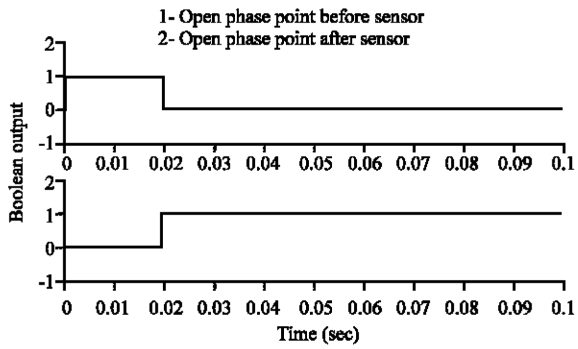

Fig. 9: Boolean outputs of open phase detector in open phase fault (phase 3 open phase fault point after the voltage sensor)

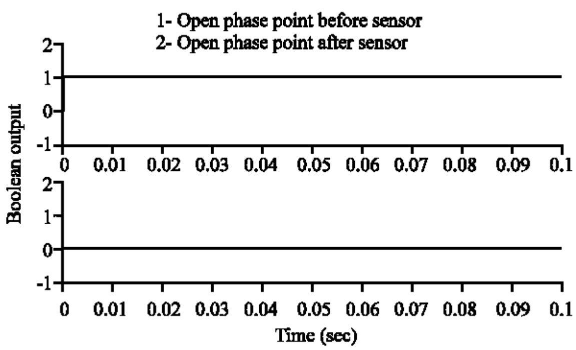

Fig. 10: Boolean outputs of open phase detector in open phase fault (phase 3 open phase fault point before the voltage sensor)

phase angle value to that in which cut point is located after the voltage sensor ($v_{sensor3} = v_{ON}$; Vrms1 = Vrms2 = Vrms3). We fixed a minimum rms value reference for phases voltages rms values ($V_{rms\ min\ ref}$ = 46 V) Fig. 7 and 8. The rms value of output voltage of the voltage sensor in the faulty phase will greater than $V_{rms\ min\ ref}$ if the cut point is located after the sensor Fig. 7 and it will be less than $V_{rms\ min\ ref}$ if the cut point is located before the sensor Fig. 8.

Boolean outputs of open phase detector in open phase fault (phase 3 open phase fault point respectively after and before the voltage sensor) are presented respectively in Fig. 9 and 10.

It is noted, in Fig. 9, that there is a delay time in fault detection of phase 3 open phase fault where cut point is located after the voltage sensor. This delay time is due to the systematic delay of rms values based classification methods since the rms value of sinusoidal signal is calculated after one cycle (period).

CONCLUSION

In this study, a new classification technique of open phase fault according to its happening point locations is proposed. This technique is based on RMS and phase angles values of three phases voltages and currents as input values of detection system that is basically based on logical functions. This method is a simple and practical one.

Simulation results are quite satisfactory. The implementation of this algorithm is simple and needs only three voltage sensors three current sensors and a software interface to display the detection system output.

REFERENCES

1. Warren, C.A., 1995. Distribution Reliability-What is it, In IEEE Rural Electric Power Conf., pp: B2-1-B2-6.
2. Leaf, J.J., 1986. Staying in power, DATAMATION, 32: 67-70.