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Study and simulation of electrical transformer protection using (differential protection)

Abdalfettah Aljedk
Electrical and Electronics Engineering, Faculty of Engineering / Bani waleed University, Libya
Abdalfettahaljedk@bwu.edu.ly

Abstract: The continuity of electric energy and its availability provision at an appropriate price is a measure of the country's progress, and the electric power system, which consists of generation units and networks for the transmission and distribution of electric power, requires enormous efforts and large and diverse equipment in order to deliver the electric current to the consumer in a correct and continuous manner. The electrical power system, including its components, such as generators, transformers, overhead transmission lines, and cables for transmitting and distributing electrical power, is exposed to some malfunctions that may cause the system to stop working due to a malfunction or damage to one of the elements of this system and consequently a power outage if the necessary preventive measures are not taken, and accordingly This paper presents a study on the differential protection of electrical transformers This is due to the importance of transformers in raising and lowering the voltage in the electrical power system and transferring power over very long distances from its generation sites to its utilization sites. where has been made Conducting of a simulation through the work of transformers and the causes that lead to malfunctions in these transformers, to arrive at the appropriate protection method for these transformers based on the study of the problems that caused these malfunctions.

Keywords: (power system, transmission lines, differential protection)

Introduction:

The electrical transformer is considered the most widespread and common element of the electrical network in its forms, sizes and functions. The electrical network contains dozens of generators, but it contains tens of thousands of transformers. Of course, only cables and overhead lines compete with it in this wide spread within the electrical power system, but the diversity in shapes, sizes and functions Electrical transformers are considered the most important among the elements of electrical power systems, and the electrical transformer is a very important part in the electrical circuit, and without it, the following vital purposes would not have been achieved:

- Transferring electrical power in huge quantities over very long distances from the sites of its generation to the areas of utilization on high electrical voltages.[1]
- Distributing electrical power over areas to benefit from it with appropriate efforts for the purposes of using it in homes and factories, and aligning any electrical device regardless of the effort it works with.[2]

Therefore, in this paper focused on how to protect electrical transformers using differential protection devices, as they are among the most important devices used in the electrical network, due to their sensitivity, reliability, selectivity and speed.

And Due to the problems that electrical transformers are exposed to as a result of lightning strikes, trees, birds and others, which leads to malfunctions on the transformers or an increase in currents and transient voltages, and electrical transformers are considered among the most important elements in the electrical network, so protecting these transformers is one of the basics of Electric power to ensure the continuity of the transmission of electric power without permanent interruption that affects consumers directly.

In this paper, a differential protection was designed on the electrical transformer and this protection was tested by placing faults inside the area in which the transformer is located (the area to be protected) and outside the area, and since we noticed that this protection works when the fault is in the area to be protected and does not work if the fault is outside it.

differential protection:

The use of surge relays does not meet all the necessary protective conditions in the electrical power system.[3-10]

We have noticed that the separation time always increases towards the source regardless of the gradient method used, and this in turn may pose a danger to the generation stations as well as to the transfer stations in addition to the direct impact on the balance of the network Therefore the method of unit protection or differential protection is used to protect Generators, transformers, engines and bus bar.[4]

- fault type and their effects:

In order to design a suitable protection system for voltage transformers, it is necessary to be aware of most of the errors that the transformer is exposed to.[6-8]

1. An external short (ground) on the ends of the high voltage coil cables.
2. An external short (between two sides) on the ends of the cables connecting the high voltage coils.
3. An internal short (ground) on one of the high voltage coils.
4. An internal short (between two faces) in the direction of high voltage.
5. A short circuit between the windings of the high voltage coil.
6. An external fault (ground) on the ends of one of the cables connecting the low voltage coils.

7- An external short (between two sides) on the ends of the cables for connecting the low voltage coils.

8. An internal short (ground) on one of the low voltage windings.
9. An internal short (between two sides) of the low voltage coils.
10. A short circuit between the windings of the low voltage coil.
11. Ground floor near the generator.
12. A palace between two faces.

Classification of faults:

Malfunctions are often classified as:

according to the number of phases affected by the fault The may be:

- single line to ground.
- Double lines to ground.
- Three lines.
- Two lines touching together Phase to Phase.
-Three lines to ground.[5]

THE RESULTS AND DISCUSSIONS:

Protection of electrical transformers using differential protection:-

The following figure shows how to protect electrical transformers using differential protection.

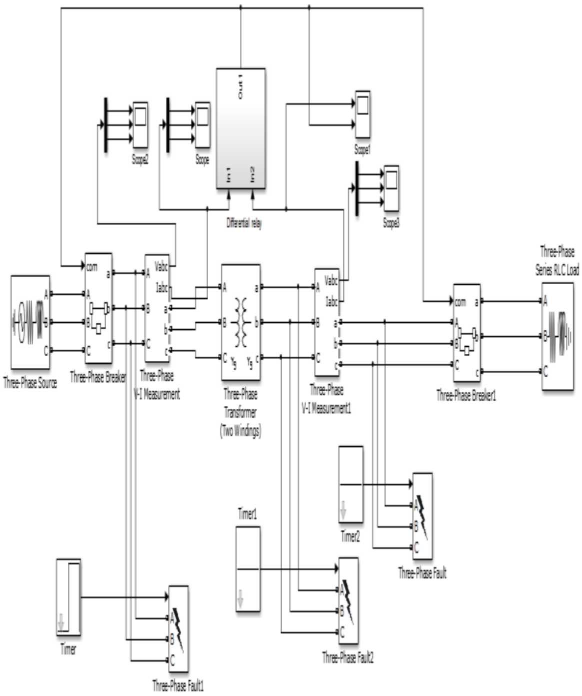

Fig (1) How to protect electrical transformers using differential protection

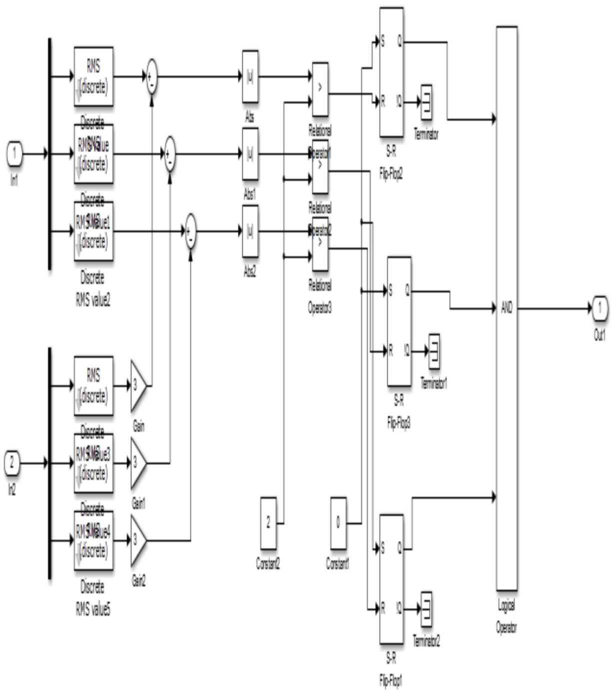

Fig (2) Internal logic Circuit

case1: In the case of no failure on the transmission line:

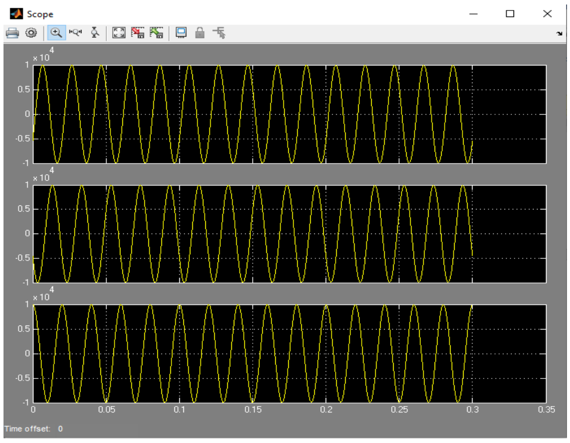

Fig (3) Stabilization of currents in the system (before the transformer).

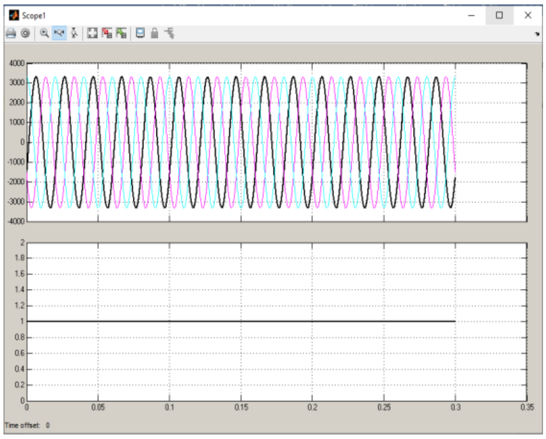

Fig (4): The currents are stable in the system (after the transformer) and the relay is not working

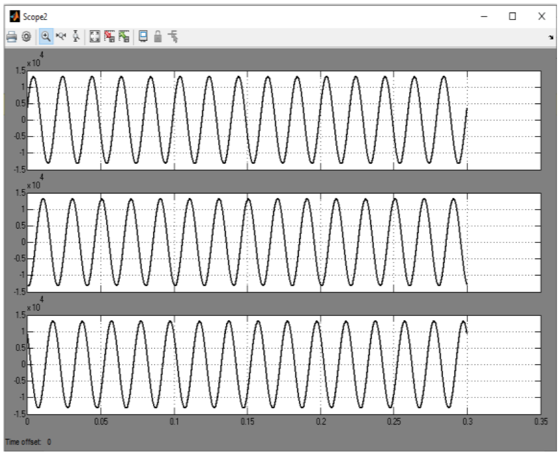

Fig (5) Stabilization of voltages in the system (before the transformer)

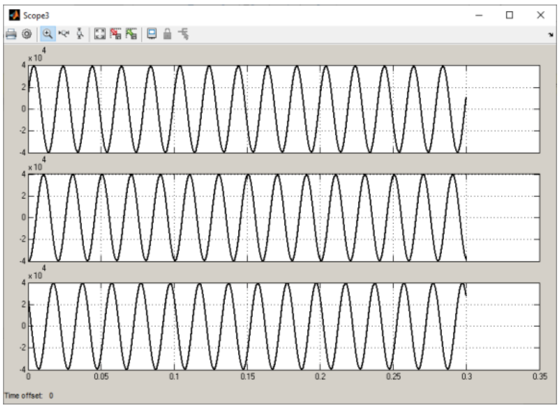

Fig (6) Stabilization of voltages in the system (after the transformer).

case2: In the case of a failure on the transmission line:

When a malfunction occurs on the transmission line, the places where the malfunction occurs can be as follows: -

1- The beginning of the transmission line and outside the protected area.

-2 Inside the protected area, i.e. next to the voltage transformer.

3- The end of the transmission line and outside the protected area.

- If we assume that there are faults in each of the previous cases on the transmission line, let us see what will happen to the currents and voltages before and after the transformer, and what can happen to the relay when the fault is inside or outside the protected area.

- In the case of the fault occurring at the beginning of the transmission line and outside the protected area, knowing that the fault could be one of the following types of faults:

- Single line to ground (S-L-G).
- Line To Line (L-L).
- Double Line To Ground (D-L-G).
- Three Line To Ground (T-L-G).[9]

it's worth mentioning that There are other types of malfunctions, but the aforementioned are the mostly need types in comparison with other types.

case3: In the case of a fault type (S-L-G) at the beginning of the transmission line and outside the protected area.

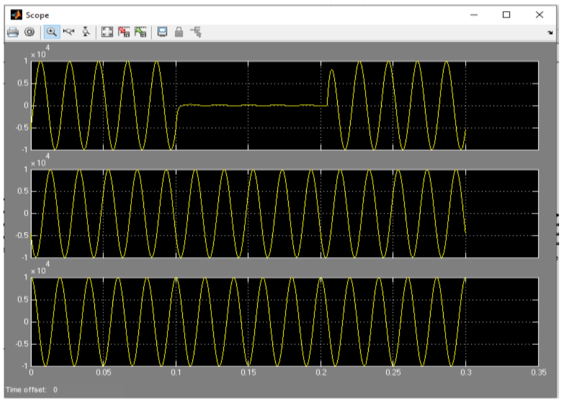

Fig (7) Waves of currents (before the transformer) and the type of fault (S-L-G).

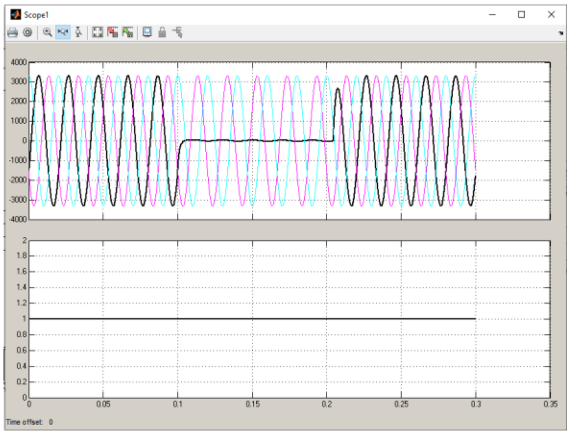

Fig (8) Waves of currents (after the transformer), the signal of the relay (not working) and the type of fault (S-L-G).

case4: In the case of a fault type (L-L) at the beginning of the transmission line and outside the protected area.

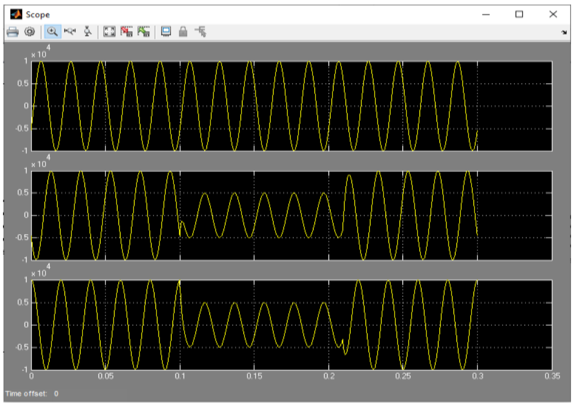

Fig (9) Waves of currents (before the transformer) and the type of fault (L-L).

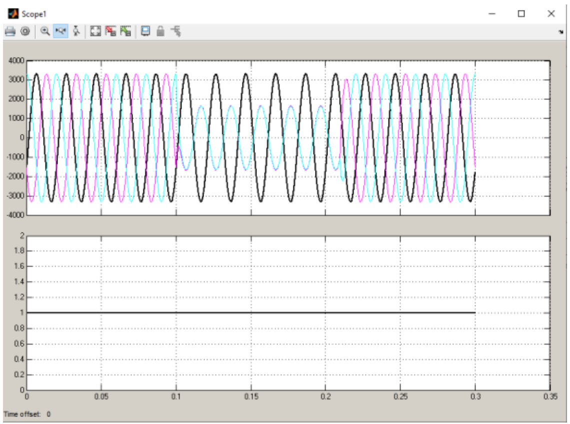

Fig (10) Waves of currents (after the transformer), the signal of the relay (not working) and the type of fault (L-L).

case5: In the case of a fault type (D-L-G) at the beginning of the transmission line and outside the protected area.

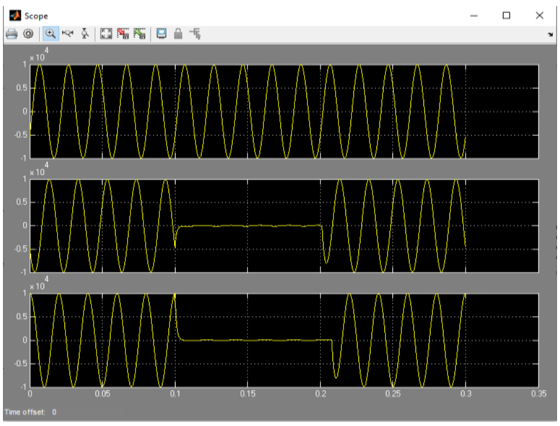

Fig (11) Waves currents (before transformer) and fault type (D-L-G)

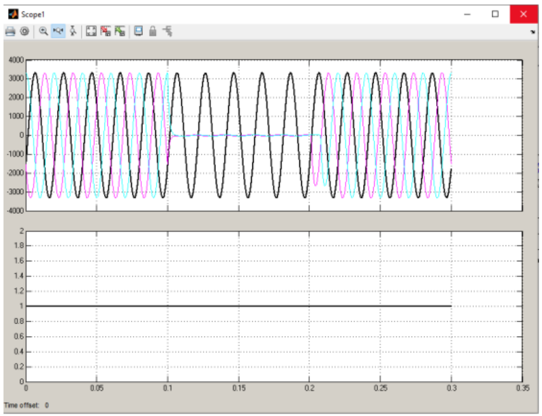

Fig (12) Waves of currents (after the transformer), relay signal and fault type (D-L-G).

Case6: In the case of a fault type (T-L-G) at the beginning of the transmission line and outside the protected area.

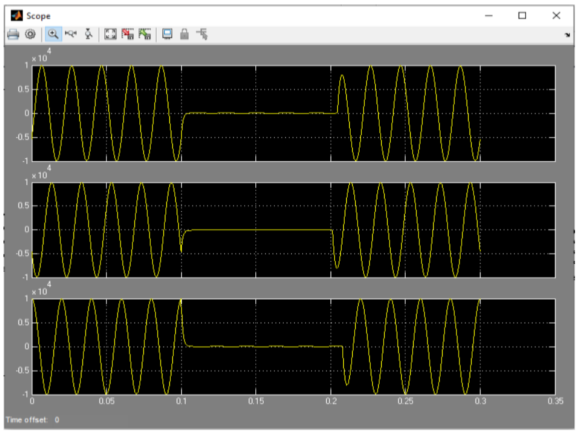

Fig (13) current waves (before transformer) and fault type (T-L-G).

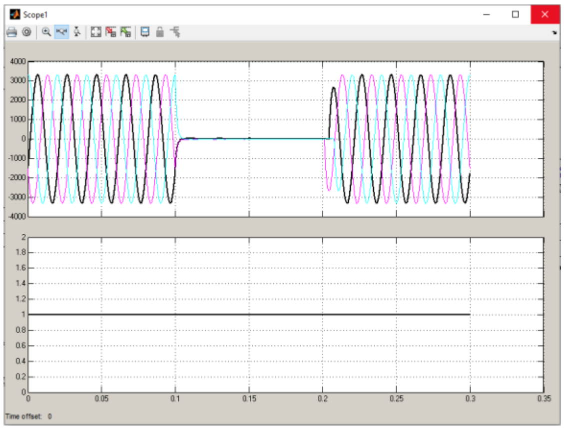

Fig (14) current waves (after the transformer), the signal of the relay (not working) and the type of fault (T-L-G).

case7: If the fault occurs inside the protected area.

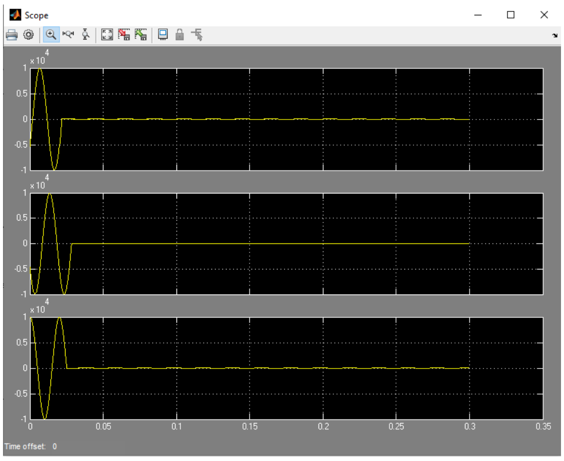

Fig (15) The occurrence of a disconnection on the system due to a malfunction.

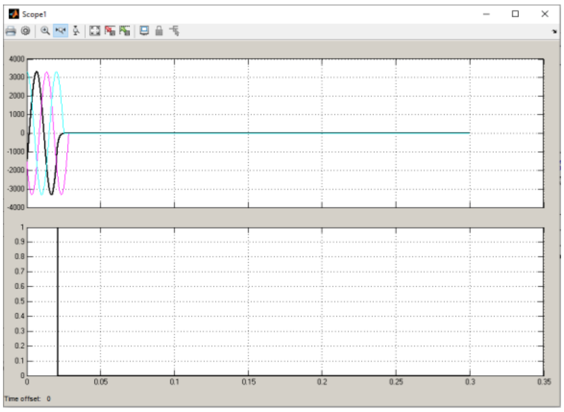

Fig (16) The occurrence of a disconnection on the system due to the work of the relay.

- Likewise, if the fault type was changed at (FauLt-2) to other types

A- Line to Line.

B- Double Line to Ground.

C- Three Line to Ground.[7]

we will notice that the relay responds to all types of faults.

Case8: In the case of a fault occurring at the end of the transmission line and outside the protected area.

A- Assuming the fault type is (S-L-G):

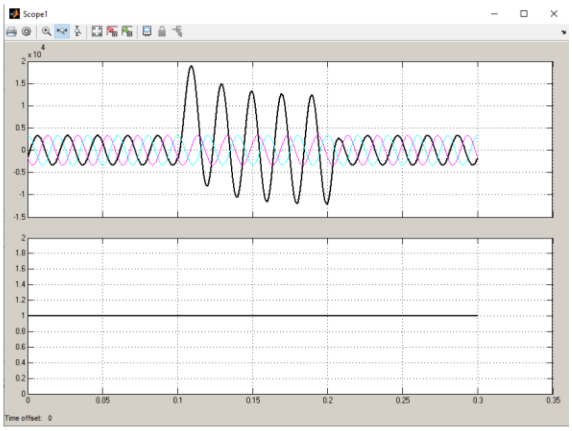

Fig (17) The current waves (after the transformer), the signal of the relay (not working) and the type of fault (S-L-G)

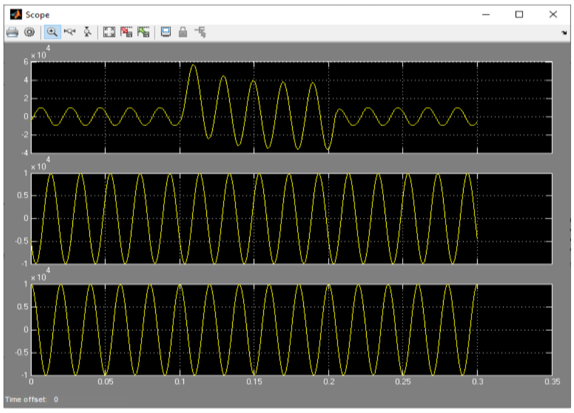

Fig (18) current waves (before the transformer) and the type of fault (S-L-G).

B- In the case of a fault type (L-L):

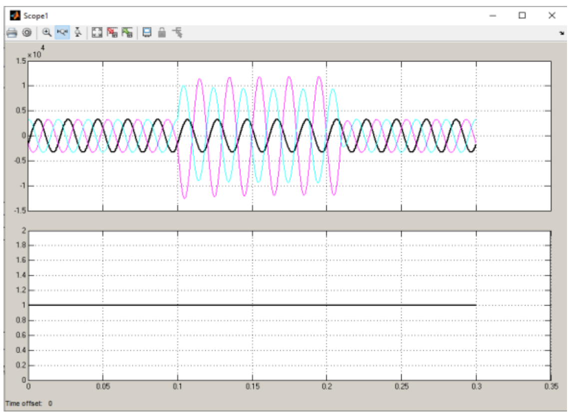

Fig (19) Waves of currents (after the transformer), the signal of the relay (not working) and the type of fault (L-L).

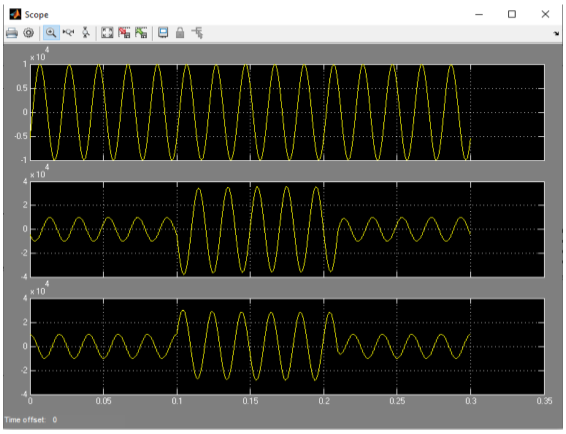

Fig (20) current waves (before transformer) and fault type (L-L).

C - Assuming the occurrence of the fault type (D-L-G):

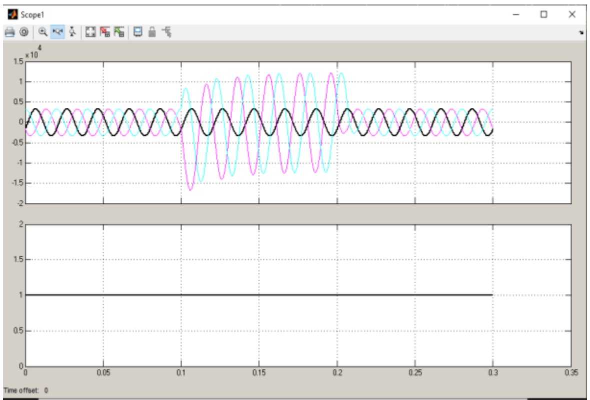

Fig (21) Waves of currents (after the transformer) and the signal of the relay (not working) and the type of fault (D-L-G).

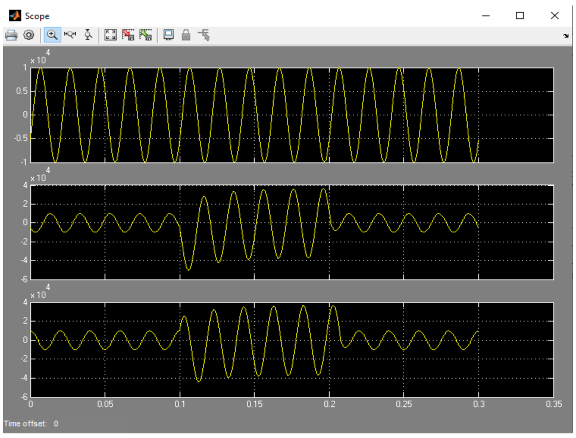

Fig (22) Waves of currents (before the transformer) and the type of fault (D-L-G).

D- In the case of a fault type (T-L-G):

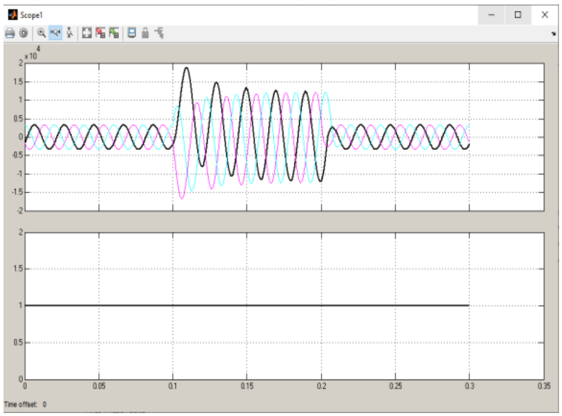

Fig (23) oscillation of the current waves (after the transformer) and the relay does not work and the fault type is (T-L-G).

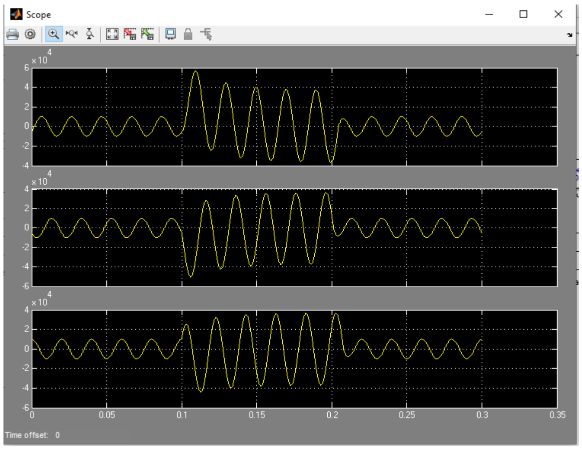

Fig (24) Oscillation of current waves (before the transformer) and the type of fault (T-L-G).

Conclusion:

A Matlab simulation of an electric transformer was presented in this work a shown in the results this simulation has been tested for many cases and for all cases it gave satisfactory results and Through the study, it became clear that the protection of electrical transformers within an integrated system is of importance, which affects the safety of these transformers and the efficiency of their work in the long run, so that they are not affected by the malfunctions of neighboring devices within the system.

And Through practical application, it was found that to reach the goal of protecting transformers, moreover are needed structure of the system to implement the transformer protection design without changing the basic course of the system, where attention must be paid to the design plan of the protection system to match the capacity of the internal system.

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