Birzeit University
Faculty of Engineering & Techonology
Department of Electrical & Computer Engineering
ENEE5102-Power Lab

“Power Transmission Line in Condition of Ground Fault”

Student: Mohamad Bornat

Instructor:Dr.Ahmad Alyan

April,2018.

Abstract

The purpose of this experiment is to get hands on the operation and study the behaviour of power transmission line under single-phase to ground fault condition with two neutral conductor connection methods; insulated neutral conductor and compensated neutral conductor. Different values of capacitance were used to sense the effect on fault current. It was found that increasing line capacitance raises the fault current. The compensated neutral conductor method resulted in a minimum fault current when resonance occurred and thus it's recommended to finely tune the value of added series inductance to satisfy the resonance condition. This will lead to the lowest fault current and thus more reliable and lower-cost protection system can be designed to isolate this fault.

Contents

Acronyms and Abbreviations

T.L	Transmission Line

List of Figures

Chapter 1

Introduction

1.1.1 Electrical Fault

The fault in electrical power system is any abnormal condition caused by equipment failures that will produce a huge amount of current, known as the fault current. This current may damage the power system equipment and devices. Thus, these devices must be protected against the fault using different types of power system protections.

1.1.2 Electrical Fault Types

There are two main types of faults:

1) Symmetrical (balanced) Faults

   In this type of faults, the effect of fault on the three phases is equal. The three line to ground fault is the example on this type of faults.

2) Unsymmetrical (unbalanced) Faults

   In this type of faults, the effect of fault on the three phases is not equal. The line to line fault, single line to ground and double line to ground are the examples on this type of faults. The analysis of this type of faults is more complicated compare to the first type. The operation of power system in single line to ground fault will discussed in this experiment.

1.1.3 Ground Capacitance

In overhead transmission lines with insulated neutral cable, there is a type of capacitance that appears between the phase and the ground called ground capacitance due to the positive charge of the transmission line conductor and the negative charge of the ground. This capacitance may form a bath of the current in fault condition, which will rise as the ground capacitance increases. The path of this current is shown in figure 1.1.

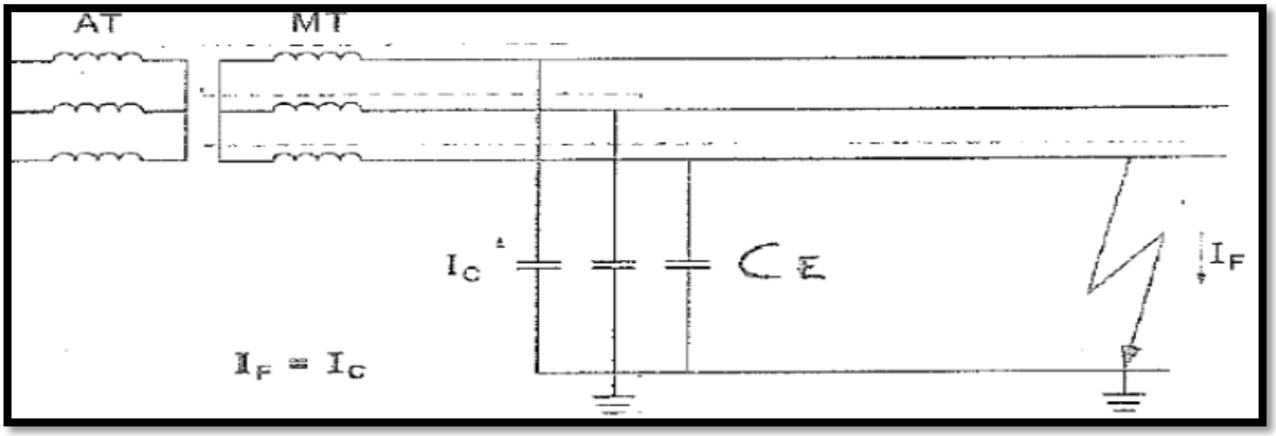

Fig. 1.1: Ground Fault Current in insulated neutral t.l

The main advantages of this transmission lines is reducing the total ground voltage for medium and high voltage faults and the transient arc produced in ground faults will be cleared automatically, but the main disadvantages of this transmission lines is difficult troubleshooting and high operating and fault overvoltage.

1.1.4 Peterson Coil

To reduce the value of the previous current, the compensated neutral conductor, called Peterson coil, will be connected to ground via the ground resistance. This coil will produce a current out of phase with the previous current and the fault current will be the sum of these two currents. The path of the fault current shown in figure 1.2.

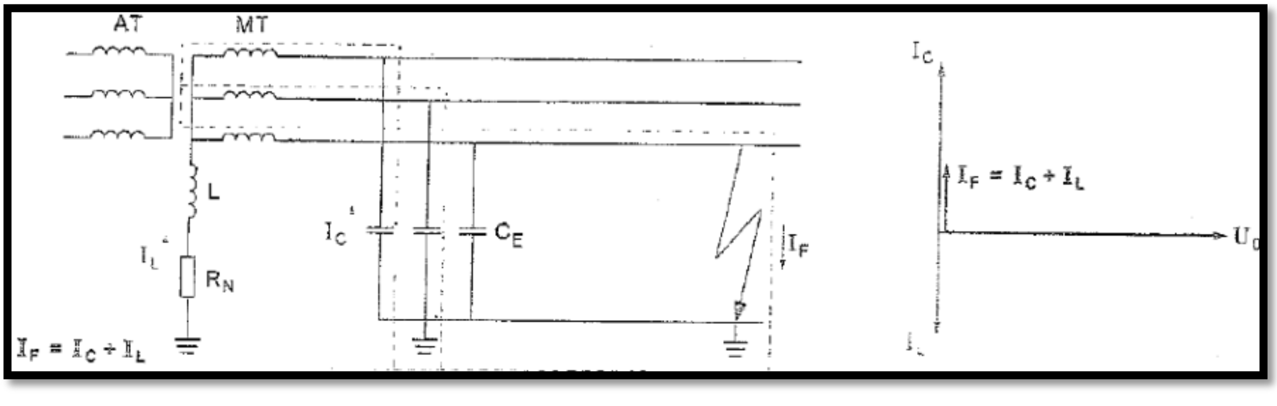

Fig. 1.2: Ground Fault Transmission Line with Peterson coil

Chapter 2

Results and Discussion

2.1 Power Transmission Line with Neutral Cable Insulated in Condition of Ground Fault

The π model of a power transmission line was connected as shown in Fig2.1. Then the voltage was set to 380V.

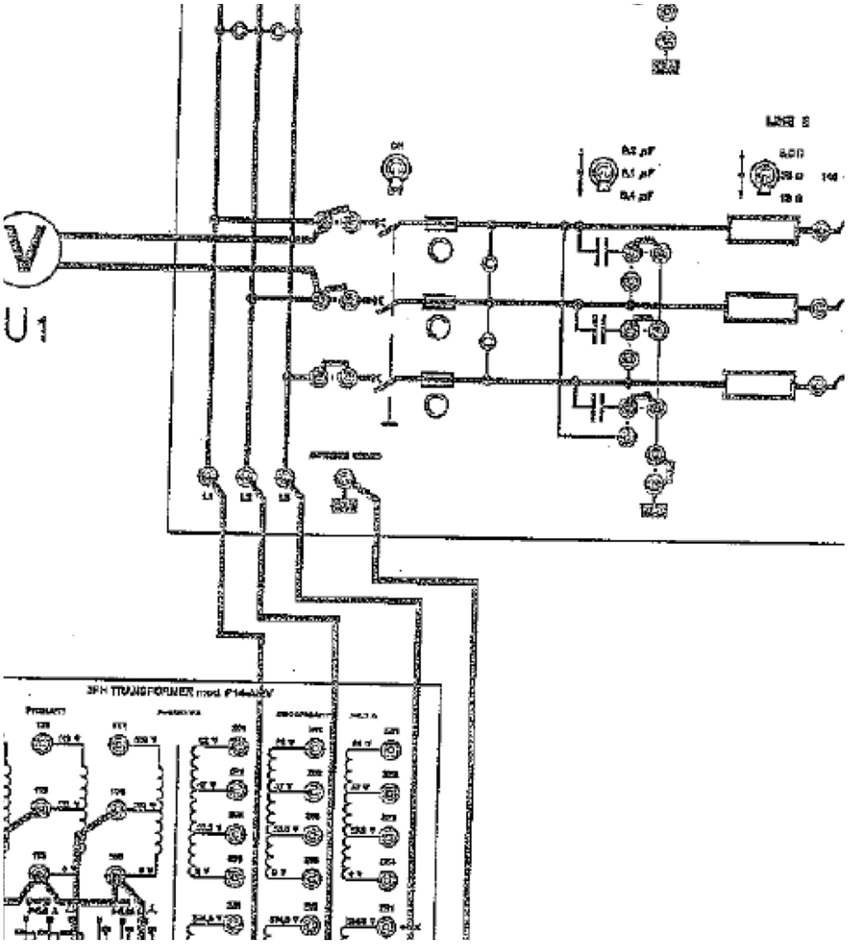

Fig. 2.1: connection diagram of a pi-modelled transmission line with insulated neutral conductor

The measuremnts of voltage , free ground fault current , trend fault current at both ends are tabulated in table 1 for different values of sending and receving ends line capacitance.

C_E sending **C_E receiving** **(µF)**	**Sending voltages** **V_S(V)**	**Free ground fault current** **$I_{F,F}$(A)**	**Trend fault current at sending end** **$I_{F,S}$(A)**	**Trend fault current at receiving end** **$I_{F,R}$(A)**
0.1, 0.1	**380**	0.015	0.046	0.046
0.1, 0.2	**380**	0.022	0.069	0.069
0.1, 0.4	**380**	0.036	0.104	0.104
0.2, 0.2	**380**	0.029	0.091	0.091
0.2, 0.4	**380**	0.042	0.126	0.126
0.4, 0.4	**380**	0.056	0.175	0.175

Table 1: The free ground fault current and trend fault current at sending and receiving ends values at different values of C_E at sending and receiving ends

Figure 2.2 illustrates the effect of total capacitance at both on the value of the fault current at receiving end of the line: the behaviour of the fault current clearly agrees with the expected theoretical analysis. In other words, the effect of increasing the value of ground capacitance results in approximately a linear increase in the value of the fault current since the impedance decrease as the value of *CE* increases thus allowing higher current to flow through it.

$$If = \frac{Vs}{Zc,eq} \,;\, Zc,eq = \frac{1}{j*w*C.eq}$$

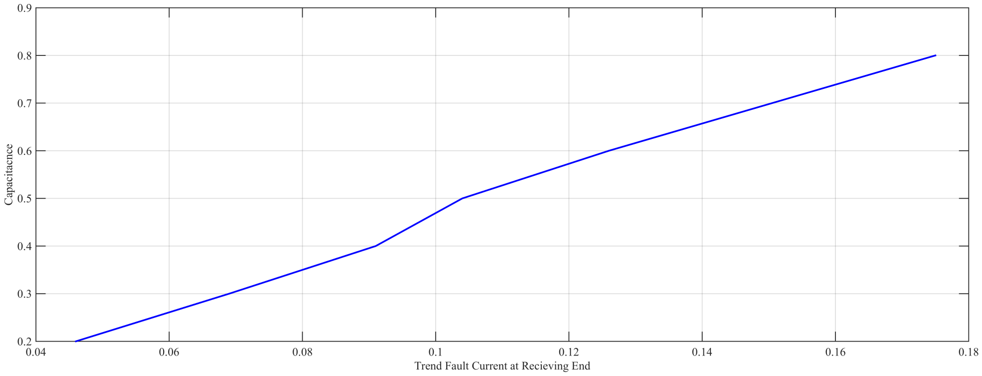

Fig. 2.2: Effect of Total Capacitance on fault current at receiving end

If a certain value of resistance is added in series with the faulted line , this will shift the curve shown in figure 2.2 down which means at every measurement the value of fault current is less due to increasing the impedance of the faults line and thus less current flows through the closes path.

$$If = \frac{Vs}{RE + Zc,eq}$$

2.2 Power Transmission Line with Compensated Neutral Conductor in Condition of Ground Fault

The π model of a power transmission line was connected as shown in Fig2.3. Then the voltage was set to 380V.

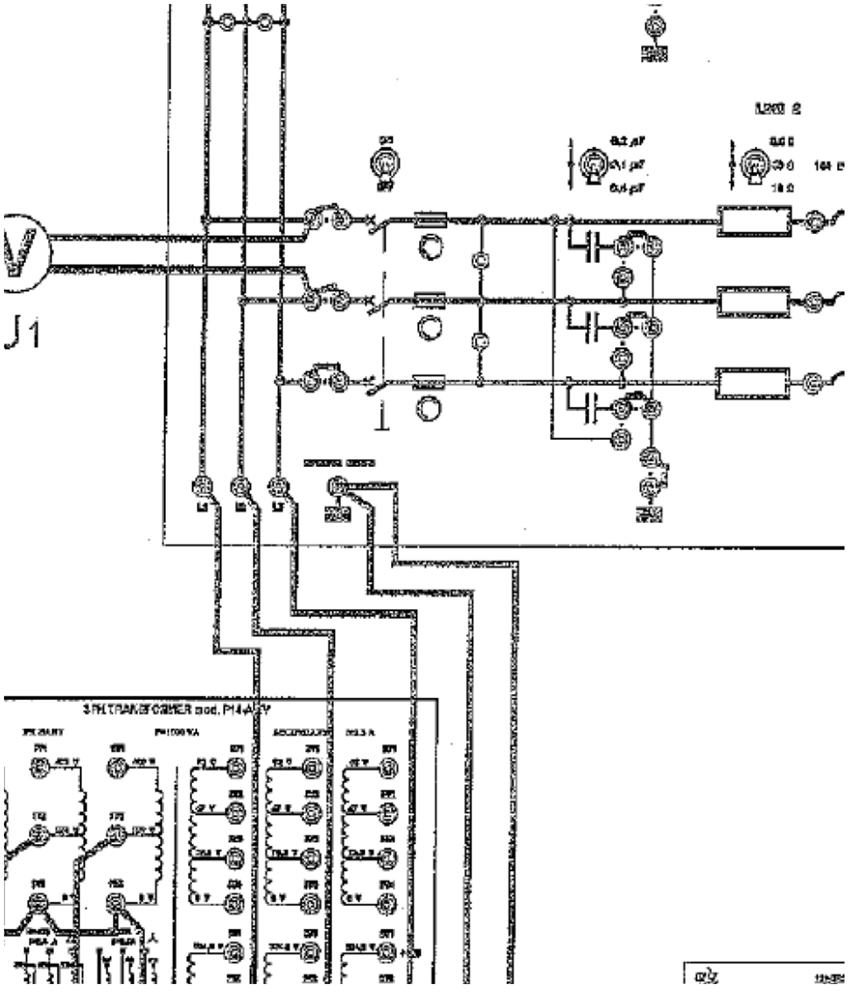

Fig. 2.3: Connection diagram of $a\ \pi\ modelled$ power transmission line under fault condtion with compensated neutral condcutor .

The transmission line parameters was set to the following values:
Resistance (R) = 18 Ohm, Inductance (L) = 0.072 H, Capacitance at sending end (C_S) = 0.4 μF and Capacitance at receiving end (C_R) = = 0.4 μF

The measuremnts of trend fault current at both ends of power tranmission line are tabulated in table 2 for different values of coil inductance at the same capacitance vlaue.

C_E sending C_E receiving (μF)	**Sending voltages V_S(V)**	**Conductance of compensation coil L (mH)**	**Trend fault current at sending end $I_{F,S}$(A)**	**Trend fault current at receiving end $I_{F,R}$(A)**
0.4, 0.4	**380**	**6.9**	0.087	0.089
0.4, 0.4	**380**	**5.75**	0.068	0.07
0.4, 0.4	**380**	**5.18**	0.059	0.06
0.4, 0.4	**380**	**4.03**	0.054	0.056
0.4, 0.4	**380**	**3.46**	0.064	0.067
0.4, 0.4	**380**	**2.3**	0.125	0.127
0.4, 0.4	**380**	**1.74**	0.215	0.217

Table 2: The trend fault current at sending and receiving ends values at different values of Peterson coil when C_E = 0.4 μF

The measuremnts of trend fault current at both ends of power tranmission line are tabulated in table 3 for different values of coil inductance at lower capacitance vlaue.

C_E sending - C_E receiving (µF)	**Sending voltages V_S(V)**	**Conductance of compensation coil L (mH)**	**Trend fault current at sending end $I_{F,S}$(A)**	**Trend fault current at receiving end $I_{F,R}$(A)**
0.2 ,0.2	**380**	**6.9**	0.028	0.028
0.2 ,0.2	**380**	**5.75**	0.037	0.038
0.2 ,0.2	**380**	**5.18**	0.049	0.05
0.2 ,0.2	**380**	**4.03**	0.08	0.081
0.2 ,0.2	**380**	**3.46**	0.11	0.11
0.2 ,0.2	**380**	**2.3**	0.19	0.191
0.2 ,0.2	**380**	**1.74**	0.282	0.283

Table 3: The trend fault current at sending and receiving ends values at different values of Peterson coil when C_E = 0.2 µF

The obtained data in tables 3&4 were analyzed and the following plot was obtained for the fault current at the receiving end as a function of coil inductance for both values of line capacitance:

The plot illustrates that the increase of series neutral inductance L decreases the fault current until reaching a minimum value at resonance condition where the path of current becomes purely resistive (Z_L=Z_{CE}). Moreover, the fault current at line capacitance of (0.4 ,0.4 uF) appears to be higher than the fault at (0.2,0.2 uF) due to the reason mentioned earlier. Notice that the resonance occurred at the highest value of L in the second case.

The condition for resonance stems from equating the inductive and capacitive impedances

For the first case, the resonant frequency is :

$$wr = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{4.03 * 0.8 * 10^{-9}}} = 17611.74\, rad/sec$$

For the second case, the resonant frequency is:

$$wr = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{6.9 * 0.4 * 10^{-9}}} = 19034.67\, rad/sec$$

It is clear that both values are fairly close to each other, however, if a smaller variation had been made for the value of *L*, the result obtained would have been more finely tuned and yield closer resonant values.

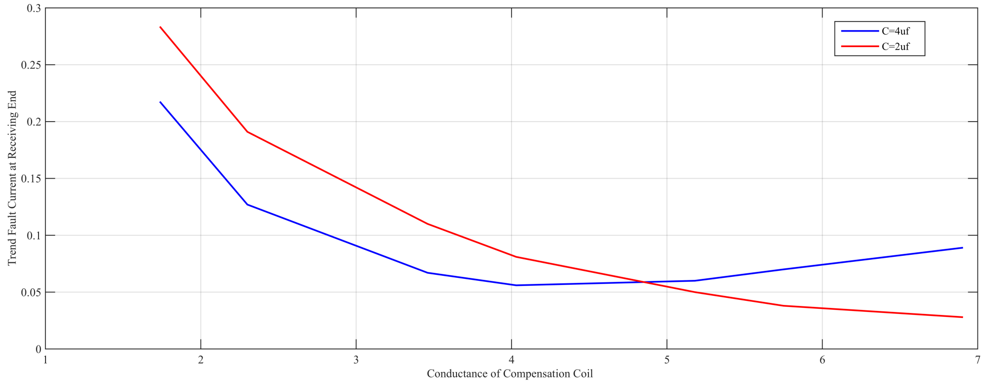

Fig. 2.4: Effect of coil inductance for both values of line capacitance on fault current in compensated neutral conductor.

Conclusion

the experiment has been centralized about studying the behavior of power transmission line under phase-to-ground fault for two neutral conductor connection schemes; insulated and compensated neutral conductors. The results have shown that increasing line capacitance results in a rise in fault current due to decreasing the impedance of the current path allowing higher current to pass. Besides, the Peterson coil method has dramatically reduced the fault current due to rising the impedance of the faulted path up to a certain value of the added series inductance , after which , the circuit becomes highly capacitive allowing a high current to flow ! . Therefore, the Peterson coil method gives lowest fault current at resonant condition

References

---

[1]Bennett S., A History of Power Systems. 1800-1930. IET. 142−148, June 1986.

[2] Advanced Power Lab Manual by dept. of electrical and computer eingineering, Birzeit university , Palestine.