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Experimental design and performance for medium transmission lines using TQ NE9080 transmission line simulator

By

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Abstract:

Early power plants were small and capable of generating electricity only for its immediate surrounding area. As the demand for electricity increased, electric utilities built larger and more efficient generating stations that replaced small ones. Since new plants were no longer adjacent to their load centers, transmission lines became necessary in transmitting power along hundreds of miles from power plants to local distribution areas.

The rapid industrialization in the 20th century made electrical transmission lines and grids critical parts of an economic infrastructure. Engineers design transmission networks to transport energy efficiently by putting into consideration some economic factors, network safety, and redundancy. Overhead transmission lines are the most commonly used means of transferring power from one location to another without interruption. Historically, A.C. systems have dominated transmission because it transforms very high voltages into useful lower ones but recent developments in power electronics have resulted in competitive distances and line construction and stringing costs are significant [1].

In this study, the researchers find the need to investigate the performance of medium three-phase transmission lines with the aid of the TQ NE9080 Transmission line Simulator, an experimental facility at the Electrical Engineering Laboratory of the MAPUA Institute of Technology, Philippines. The study also includes comparison/analysis on the performances of the different types of medium transmission lines.

Keywords:

Transmission Line Simulator, Medium Transmission Line.

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1. Introduction:

Electric power is commonly transmitted from one location to another without interruption through overhead transmission lines. These lines are classified by the distance of transmission from the sending end up to the receiving end of the line. A short transmission line has a limited distance of 80 km while a medium transmission line has 81 to 240 km distance. However, a long transmission line has a limited distance of 240 km and above [2].

There are three types of Medium transmission lines: (1) End Condenser, (2) Nominal 'Pi', and (3) Nominal 'T'. The parameters of these medium transmission lines are resistance, inductance and capacitance.

This study aims to evaluate the performance of medium transmission lines using the TQ NE9080 Transmission Line Simulator. Furthermore, it aims to carry out investigations on the effects of various transmission line parameters in the overall performance of the system and to compare/analyze the performance of the different types of medium transmission lines.

The TQ NE9080 Transmission Line Simulator is an experimentation facility permitting investigation into line performances and characteristics of single and three-phase systems. This leads to an understanding of designing a power system with specific voltage at specific points for all possible load variations. An important aspect of power system design involves consideration of the service reliability requirements of loads that are to be supplied [3].

This paper also covers the development and evaluation of experimental designs for the three types of medium lines. However, the evaluation is limited to the performance of each type by varying the parameters of the line (Resistance, Inductance and Capacitance) and their effects on the following: (a) receiving end voltage, (b) output frequency, (c) power output, and (d) line loss. The Data Management System (DMS2) Software was utilized in simulating the performance graphs of the transmission for analysis. Although the computations used in this study were primarily for three-phase systems, such calculations can also be applied to single-phase systems by using conversion formulas. The TQ NE9080 Transmission Line Simulator with a range limit of 6.5 Amperes and the Data Management System 2 (DMS 2) equipment were used in conducting the experiments for this Study. The performances of the short and long transmission lines and conductance parameters are not covered by this study.

2. Methodology:

In the Transmission Line Simulator, the line parameters are placed throughout in "Pi" or "T" configuration. It is recognized that these does not accurately represent real lines having uniformly distributed characteristics. Before conducting a series of experiments, the researchers observed precautionary measures by understanding the basic safety rules in using the test equipment [4]. The researchers used the TQ NE9080 Transmission Line Simulator and the Data Management System (DMS2) that provided digital outputs in the measurements of current, voltage, power factor and real power in the system.

The first step taken was to consider design experiments in investigating the performance of Medium Three-Phase Transmission Lines with the aid of the TQ NE9080 Transmission Line Simulator. The researchers considered three types: (a) End Condenser, (b) Nominal 'T', and (c) Nominal 'Pi'. Additionally, the DMS2 equipment was used in simulating the performance graphs for further analysis.

The researchers then analyzed the performance of each type by varying the parameters of the line (Resistance, Inductance, Capacitance), and then recorded the effects of these parameters on the receiving end voltage, output frequency, power output, and line loss. At the same time, the DMS2 equipment with its software was used in simulating the performance graphs of the transmission line for further analysis. Furthermore, the TRANSPRO Software was used as a tool in verifying the results [5]. The researchers also provided experimental tables in evaluating each type. The researchers then computed the design experiments of Medium Three-Phase Transmission Lines which were converted into single-phase using conventional formulas.

Finally, the results of the experiment for each type of Medium Transmission Line were compared and analyzed before the development of conclusions and recommendations. The statistical tool used in evaluating the results was the statistical mean or mean average. At the start of the experiment, the equipment was set, then the constant values were initialized using the following formulas:

$X_L = 2 * \pi * f * L$ …………………………………….(1)
$X_C = 1 / (2 * \pi * f * C)$ …………………………….(2)
$B = 2 * \pi * f * C$ ……………………………………...(3)

$P_{LOSS} = P_S – P_R$ ………………………………………..(4)
$V_D = V_S - V_R$ …………………………………………(5)
$PF = P_R / (V* I)$ ……………………………………(6)
$\eta_{TL} = (P_R / P_S) * 100\%$ …………………………….(7)
$I_{C1} = \pi * f_R * C * V_R$ ………………………………(8)
$I_{C2} = \pi * f_S * C * V_S$ ………………………………..(9)
$I_C = 2 * \pi * f_R * C * V_R$ ……………………………(10)
$\%VR = ((V_S – V_R) / V_R) * 100\%$ ………………… (11)

The constants were placed in the initializing area for storing the values in their respective variable. Then the values were registered in the input area in their respective variables which serve as line parameters and other requirements in the lines. After that, the conversion of the line parameters was calculated then all the necessary requirements for the sending end or receiving end in the line were computed. In the next step, the transmission lines requirements such as the voltage drop (V_D), % voltage regulations (%VR), power losses (P_{LOSS}), and the transmission line efficiency (η_{TL}) were determined. Lastly, the average of the results was calculated followed by the analysis and comparison of the results.

In computing for the value of the line constant of resistance and inductance parameters, it was noted that the total line inductance was 38.2 mH, hence its equivalent inductive reactance X_L was computed and was determined to be 14.4 ohms by using the formula $X_L = 2 * \pi * f * L$ with f = 60 Hertz.. The researchers used the nominal 'T' configuration to verify the constant parameter. The inductive reactance on the other side of the line was found to be 7.2 ohms. The receiving current (I_R) was observed to be equal to the current $I_Ø$ (4.31 amperes) entering in the half line located at the receiving end, therefore $I_Ø$ is equal to I_R. The voltage drop across the inductive reactance was then measured with the use of an analog meter. The measured voltage was around 33 volts. The impedance per phase ($Z_Ø$) on the line was then determined. Using the formula $Z_Ø = V_Ø / I_Ø$, the impedance was computed and was found to be approximately (33 V/ 4.31 A) = 7.65 ohms.

Since $Z_Ø$ = 7.65 ohms and the inductive reactance on the other side of the line = 7.2 ohms, the resistance in the line was computed by applying the concept of Power Triangle and the Pythagorean Theorem. The line resistance was calculated to be equal to approximately 2.585 ohms. In the foregoing steps, the total resistance (R) and inductive reactance (X_L) of the line were determined to be 5.17 ohms and 14.4 ohms respectively. These parameters are constant. However, the capacitance used in the line was varied depending on the manner in which the capacitance was taken into account.

It was noted that the ratio X_L / R (14.4 ohms / 5.17 ohms) = 2.785. It was also observed that the ratio X_L / R was at around 3.4 when the line voltage was at 132 KV and it was down to 1.9 when the line voltage was at 33 KV. Hence, from ratio 2.785, the researchers computed its corresponding voltage by applying mathematical interpolation using the other ratios and their corresponding voltages as references. The computed voltage of 91.41 KV appeared to meet the required range of operating voltage for medium transmission lines, which is less than 100 KV.

Part I. Varying the Value of Capacitance

Case I. End Condenser Configuration

The sending and receiving ends of the transmission line simulator were connected to the analog measuring instruments for readings the real power, voltage, current, and frequency. The DMS2 was connected to the sending end and receiving end of the lines interfaced to the computer. The computer used the DMS2 software in simulating the readings in digital form. After setting up the necessary equipment, the researchers conducted five trials for each experiment performed.

The values for each capacitance per design were 4 µF, 8 µF, 12 µF, 16 µF, and 20 µF respectively. The parameters resistance and inductive reactance in the line were constant. The researchers took the readings from the wattmeter, voltmeter, ammeter and frequency meter in both ends of the lines. Since analog instruments were used in recording test data, the other requirements in the lines (like conversion of inductance (L) into reactance (X_L), capacitance (C) into reactance (X_C) and susceptance (B), capacitance charging currents (I_C, I_{C1}, I_{C2}), power factor (pf), voltage drop (V_D), power loss (P_{LOSS}), voltage regulation (%VR), and transmission efficiency (η_{TL})) were determined using applicable formulas shown above. After computing all the required values in the line, the researchers calculated the average of the obtained results.

All of these required values and transmission line calculations were used in computing for the other line requirements in the remaining experiment. All data for each experiment were tabulated. Furthermore, the researchers plotted the result in a performance graph. Included in the graph were the V_D, %VR, Power Loss (P_{LOSS}), and transmission line efficiency (η_{TL}) as y-coordinate with respect to capacitance as the x-coordinate. After obtaining the performance graphs, an analysis of the results was made.

Case II. The Nominal 'T' Configuration

In this experiment, the capacitance was concentrated at the middle of the line and half the line resistance and reactance were lumped on either side. The capacitance was varied from 8 µF , 12 µF, 16 µF , 20 µF, and 24 µF. The resistance and inductive reactance parameters in the line were kept constant. Afterwards, the performance graph of this experiment was obtained. Included in the graph were V_D, %VR, Power Loss (P_{LOSS}) and transmission line efficiency (η_{TL}) as y-coordinate with respect to capacitance as the x-coordinate. An analysis of the results was made after these performance graphs were obtained.

Case III. The Nominal 'Pi' Configuration

In this experiment, the capacitance was divided into two halves, one was lumped at the sending end and the other half at the receiving end. The value of capacitance was varied from 8 µF, 16 µF, 24 µF, 32 µF, and 40 µF respectively. The parameters in the line resistance and inductive reactance were constant. Similar with the previous experiments, all required values in the line were computed as well as the average of transmission line results. The performance graphs of this experiment were obtained. An analysis of the results was made after these performance graphs were obtained. Furthermore, the researchers analyzed and compared the results with the previous experiments.

Part II. Variation of load (Case IV: End Condenser, Case V: Nominal 'T', and Case VI: Nominal 'pi' Configurations)

In this procedure, the electrical impedance load of end condenser, nominal 'T', nominal 'pi' configurations was varied. The parameters in the line resistance, inductance and capacitance were constant. There were five experimental designs conducted on each configuration. After setting up the equipment and making all the necessary connections, the researchers took all the readings and computed all the necessary required values in the lines as well as the average of the transmission line results. Each experimental design has its corresponding tabulation. The performance graphs of these experiments were obtained and explained. Included in the graph are V_D, %VR, Power Loss (P_{LOSS}) and transmission line efficiency (η_{TL}) as y-coordinate with respect to receiving current (I_R) as the x-coordinate. An analysis of the results was made after these performance graphs were obtained. Furthermore, the researchers analyzed and compared the experimental design results on the three configurations.

Results and Discussion

Part I. Varying the Value of Capacitance

Case I. End Condenser Configuration

Results imply that varying the value of capacitance affect the performance of the line at the receiving end. It was observed that the power factor angle decreased from 12.578, 10.58, 10.58, 15.42, and 6.28 respectively except in trial 4, but then, it continued to decrease in trial 5. This implies that the power factor at the receiving end has improved. At the sending end, even if the value of capacitance was increased by 4 microfarad, there was a minimal effect in its constant value increase in voltage (134, 134, 135, 135, 135 volts), current (5.7, 5.75, 5.8 5.9, 6.1 amperes), power (620, 630, 655, 670, 700 watts), frequency (57.2, 57.2, 57.5, 57.7, 57.8 hertz), and power factor (0.812, 0.818, 0.836, 0.841, 0.850). This implies that the input was not so affected by the increase in capacitance because the magnitude of the input voltage has no effect on the inductive and capacitive reactance in the line. It has also been noted that the power factor angle decreased (35.71, 35.11, 33.28, 32.75, and 31.79), thereby implying that the power factor of the system has improved.

In terms of transmission line calculations, an increase in the value of capacitance meant a decrease in voltage drop (37, 36, 35, 33, 31 volts) and percent voltage regulation (38.14, 36.73, 35, 32.35, 29.81). The power loss fluctuated but had a tendency to decrease (90, 81, 85, 95, 80 watts), while efficiency fluctuated but tended to increase in performance (85.48, 87.14, 87.02, 85.82, 88.57). This shows that an increase in the value of capacitance resulted to an increased performance of the transmission line.

Case II. Nominal T Configuration

It was noted that in the case of Nominal "T", an increase in the value of capacitance resulted to an increase in voltage, current, charging current, power and frequency at the receiving end, while the power factor slightly fluctuated. The power factor angle has been noted to be fluctuating but the value has been decreasing. This result implies that the power factor of the system has improved due to an increase in capacitance.

At the sending end, variation in capacitance does not greatly affect the voltage, current, power, power factor and frequency. The power factor angle has a diminishing value except for the second trial which implies that the power factor of the system has improved.

In the transmission line calculations, the voltage drop and percent voltage regulation smoothly diminished. Its power loss has been noted to be fluctuating but in general it was a sign of power factor improvement in the system. Its efficiency also fluctuated in ascending performance.

Case III. Nominal ‘pi’ Configuration

In the Nominal ‘pi’ configuration, results showed that an increase in the value of capacitance meant an increase in voltage, current, charging current (I_{C2}), line current, power and frequency at the receiving end. At the sending end, an increase in capacitance value resulted to a minimal increase in voltage (135, 135, 136, 136.5, 136 volts), power (640, 660, 670, 685, 700 watts), power factor (0.829, 0.858, 0.864, 0.888, 0.911) but a decrease in current (5.72, 5.7, 5.7, 5.65, 5.65 amperes). The frequency (58.9, 59, 59, 59, 59 hertz) was constant. Its power factor angle decreased (34, 30.91, 30.23, 27.38, 24.36 degrees) to a great extent which implies an improvement in the power factor of the system.

Part II. Variation of Load

Case IV. End Condenser Configuration

At the receiving end, it was noted that when the load was increased, the receiving current I_R increased. Its charging current, power, and power factor also increased to a minimal extent. Its voltage drop, power factor angle, and frequency decreased. At the sending end, it was observed that the voltage and frequency decreased while the power and current increased. The power factor and power factor angle fluctuated. In transmission line calculations, the voltage drop, percent voltage regulation, power loss and efficiency increased.

Case V. Nominal ‘T’ Configuration

At the receiving end, it was found out that once the loads have been increased, the voltage, power factor angle and frequency decreased. The current, power and power factor increased, while charging current fluctuated.

At the sending end, the voltage (133, 131, 130, 128, 126 volts) and power factor angle (68.41, 67.79, 58.94, 52.77, 38.92) decreased when loads were increased while the current (0.92, 1.98, 2.98, 4, 5 amperes), power (45, 98, 200, 310, 490 watts) and power factor (0.368, 0.378, 0.516, 0.605, 0.778) increased. The frequency (57.1, 57.5, 57.2, 57, and 56.9) has been noted to be almost constant. In the transmission line calculations, when the load was increased, the voltage drop (7, 12, 21, 29, 34, volts), percent voltage regulation (5.56, 10.08, 19.27, 29.29, 36.96) and efficiency (44.44, 56.12, 70, 83.87, 84.69) increased. While power loss (25, 43, 60, 50, 75) increased in the first three (3) trials and decreased in the fourth trial. In trial 5, the power loss increased again.

Case VI. Nominal 'pi' Configuration

Results showed that an increase in load resulted to an increase in line current, power and power factor but showed a decrease in voltage, power factor angle and frequency at the receiving end. The charging current (I_{C1}) seemed to be constant while charging current fluctuated. Furthermore, the sending end showed an increase in power and current. The voltage has decreased. The power factor and power factor angle fluctuated. The frequency was almost constant. In transmission line calculations, increase in loads denotes and increase in voltage drop, percent voltage regulation, power loss and efficiency.

Performance Curves

Part I. Varying the Value of Capacitance

Case I. End Condenser Configuration

In the performance curves of this experiment, results showed that an increase in the value of capacitance leads to a decrease in voltage drop, thereby, increasing the performance of transmission line.

The second performance curve showed that the %VR is directly proportional to V_D. As %VR decreased, the performance of the transmission line efficiency increased.

The third performance curve shows power loss (P_{LOSS}) versus varied capacitance value. Results show that with the varied capacitance 4, 8,12,16,20 μF used, there was a fluctuating power loss (P_{LOSS}) indicated from 90, 81, 85, 95, 80 watts respectively. The power factor at the receiving end was indicated as 0.976, 0.983, 0.983, 0.964 and 0.994 respectively. Power factor of trial four (4) decreases, therefore it has a higher power loss. From the formula P = VI cos Ø, cos Ø or power factor is inversely proportional to the product of voltage and current. Wherein $P = I^2 R$, I is directly proportional to P. In the last trial, the power loss decreased, therefore the power factor increased. Hence, even if the power loss is fluctuating, it tends to decrease in the last trial, therefore, the performance is improved.

In the last performance curve, an increase in the value of capacitance 4, 8,12,16,20 μF, resulted in an increased value of transmission line efficiency from 85.48, 87.14, 87.02, 85.82 and 88.57 percent respectively. It was observed in trial four (4) that the efficiency decreased because the power factor decreased (0.964). But in the last trial, the efficiency rose as the highest, thus, increasing the capacitance at the receiving end. This tends to increase the transmission line efficiency.

The researchers found out that as the value of the capacitance increased at the receiving end, the voltage drop and %VR decreased, while the power loss and η_{TL} fluctuated in trial 4, but then power loss decreased in trial 5 which indicated that transmission line efficiency increased. Thus, these parameters tended to increase the efficiency of the line.

Case II. Nominal 'T' Configuration

The parameters used in these performance curves were similar to Case I but the capacitance values were different. The capacitance were varied from 8, 12, 16, 20, 24 μF respectively. In the performance curve of voltage drop versus capacitance value, it was observed that an increase in the value of capacitance resulted to a decrease in voltage drop (38, 37, 36.5, 36. 35 volts). Thus, the capacitance tended to decrease the magnitude of the sending end current. Therefore, as the voltage drop decreases, the performance in the line becomes better. In the performance curve of %VR versus capacitance value, it was observed that as the value of capacitance increased, the %VR decreased (40, 38.14, 37.44, 36.73, and 35.35). The parameter V_D is directly proportional to %VR. Thus, as the value of capacitance increases, the %VR decreases. This gives a good performance in efficiency on the line.

In the performance curve of P_{LOSS} versus capacitance, it was observed that there was a rise and fall effect on power loss due to an increased capacitance. The last two trials were the same (115, 87, 90, 100, 100 watts), the first trial has the highest value of power loss 115 watts, while the second trial has a power loss of 87 watts. The average of these values is 101 watts, thus, the power loss on the line in the last two trials tend to direct the average from the highest to the lowest value. In the performance curve of η_{TL} versus capacitance, it was observed that the efficiency fluctuated (81.89, 86.30, 85.937, 84.85 and 85.075 percent). However, the efficiency indicated a good performance on the line. In the analysis of this configuration, an increase in the value of capacitance resulted to a decrease in V_D and % VR. The power loss fluctuated but tend became constant, then to average. The efficiency also fluctuated but will fell to the highest performance.

Case III. Nominal 'pi' Configuration

In this experiment, the parameters of the performance curves are similar to Case I and Case II except for the capacitance values. The varied capacitance were 8, 16, 24, 32, 40 µF respectively. The performance curve on the voltage drop versus capacitance showed that an increase in the value of capacitance resulted to a decrease in V_D as indicated by a concave downward line (37, 36, 36, 26.5, 11 volts). Hence, once the capacitance is increased, the charging current at the receiving end I_{C2} tend to decrease the magnitude of the line current of the transmission line. In this effect, decreasing the line current tend to decrease the voltage drop on the line. Therefore, decreasing the voltage drop in the line improves the performance of the line as shown in Figure 14. Likewise, in the performance curve of %VR versus capacitance, it was observed that an increase in capacitance resulted to a decrease in %VR as indicated by the concaved downward line (37.75, 36.36, 36, 24.1, and 8.8). Thus, parameters of %VR is directly proportional to V_D. A decrease in %VR results to good performance and high efficiency.

On the other hand, the performance curve of P_{LOSS} versus capacitance value shows that once the value of capacitance is increased, the power loss value fluctuates. It rises and falls but in the last two trials, they were the same (92, 100, 80, 90 and 90 watts). The power loss in the first trial was 92, then it rose to 100, then fell to 80, but finally rose to 90 to be constant. However, the value of trials 2 and 3 (100 and 80 respectively) yielded an average of 90 watts. Thus, the power loss of this configuration tended to be of constant value at the highest value of capacitance. In the performance curve of the η_{TL} versus capacitance value, an increase in capacitance resulted to a fluctuating η_{TL} values (85.625, 84.85, 88.06, 86.86, and 87.14 percent). However, the transmission efficiency improved. In the analysis of the results, the effect of varied increasing capacitance in the nominal 'pi' transmission line are as follows: (1) the V_D and the %VR decreased; (2) the power loss fluctuated but tended to be of constant value by getting the average of the highest and lowest value, (3) The efficiency also fluctuated but rose up which indicated a good performance.

Part II. Variation of Load

Case IV. End Condenser Configuration

In the performance curves of this experiment, the researchers used the receiving current (I_R) as the abscissa coordinate versus V_D, %VR, P_{LOSS} and η_{TL} respectively as the ordinate. In the performance curve of V_D versus I_R, it was observed that as the load was increased, the receiving current also increased, (1, 2, 3, 4, 5 amperes). This is based from the formula $I_R = (P_R / (V_R * \cos Ø))$. As P_R increased, I_R increased thus, P_R is directly proportional to I_R. Therefore, an increase in receiving current affects the transmission line, thus the voltage drop also increase (4, 7, 17, 23, 33 volts). Furthermore, as the load was increased, the I_R and V_D also increased. However, the capacitance connected in the circuit at the receiving end worked to lessen the magnitude of the current in the line, therefore, it helped to improve the power factor to increase the efficiency of the line. In the performance curve of %VR versus I_R, it was observed that as the receiving current I_R was increased, %VR also increased (3.10, 5.55, 15.04, 21.49, and 34.37 percent). It turned out that I_R was directly proportional to % V_R .

The result of the performance P_{LOSS} versus I_R, indicated that as the load was increased, the power loss in the line also increased but fell to be constant in the last two trials (20, 35, 45, 70, 70 watts). This meant that the resistance in the line was saturated. The efficiency of the line increased as the load increased. The researchers analyzed that as the load is increased, the receiving current (I_R) follows to increase. This affects the line current in the transmission line. However, the capacitance connected at the load side worked to improve the power factor in the system thus, improving the efficiency of the line.

Case V. Nominal 'T' Configuration

The performance curve of V_D versus I_R showed that as the receiving current (I_R) increased, (1, 2, 3, 4, 5 amperes), the voltage drop (V_D) in the line increased (7, 12, 21, 29, and 34 volts). The result shows an almost straight line inclined upward. On the other hand, the performance curve of %VR versus I_R indicates that as the current is increased (1, 2, 3, 4, 5 amperes), the %VR of the lines follows to increase (5.56, 10.08, 19.27, 29.29, and 36.96). Likewise, the performance curve of P_{LOSS} versus I_R, shows that when there is an increase in receiving current I_R (1, 2, 3, 4, and 5 amperes), the power loss in the line also increases. However, it decreased in trial 4, and then, it increased again in trial 5. In principle, as the load is increased, the current follows to increase. This affects the current in the line to increase. Therefore, power loss in the line is also increased. On the other hand, an increase in the receiving current (1, 2, 3, 4, 5 amperes) resulted to an increase in efficiency. The researchers analyzed that as the load was increased, the receiving current also increased. Thus V_D and %VR is directly proportional to I_R. The power loss continued to increase but decreased in trial 4. However, it was observed that it increased again in trial 5. The connection of capacitance at the middle point of the line increased the system efficiency and it also resulted to a good system performance

Case VI. Nominal 'pi' Configuration

The performance curve of voltage drop versus $I_{R,}$ it indicates that an increase in receiving current I_R (1, 2, 3, 4, 5 amperes) also increases the voltage drop in the line (6, 17.5, 26, 39 and 60 volts). Likewise as I_R increases, the %VR follows to increase (4.58, 14.71, 23.85, 40.62 and 80 percent). .

On the other hand, the performance curve power loss versus I_R shows that an increase in I_R resulted to an increase in power loss. However, in trials 4 and 5, power loss becomes constant (10,15,38,60, 60 watts). This means that the resistance in the line is saturated. The transmission line versus I_R performance curve shows that as I_R is increased, the efficiency also increased with the aid of the capacitance situated at the receiving and sending ends of the line. The researchers analyzed that when the load is increased, the $I_{R,}$ %VR and power loss also increased. The capacitance at the receiving and sending ends worked to improve the power factors that increased the efficiency of the line.

3. Conclusions:

Based from the results of the study, the researchers conclude the following:

The study utilized ten (10) experimental designs for each type of medium transmission lines, five (5) of which were used with varied values of capacitance and five (5) were used in varied loads. The transmission line parameters, capacitance in particularl, greatly affected the overall performance of the system which include voltage, power output, power losses and frequency. An increase in the value of the capacitance resulted to an increase in the performance of the system as indicated by the findings of the study.

Part I. Varying the Capacitance

It has been observed that when the value of line capacitance is increased, the End Condenser has the best performance in terms of efficiency when compared with other medium line configuration. The Nominal 'Pi' configuration has the lowest voltage drops. However, the nominal 'T' configuration has the highest percentage in terms of power loss which lowers the system's overall performance.

Based from the performance curves, the researcher noted that when the value of capacitance in the line is increased (trial 1 to 5), the performance curve of the End Condenser and nominal 'T' in terms of V_D and %VR were almost in straight line inclined downward whereas the performance curve of the Nominal 'Pi' was almost concaved downward with the lowest value of intersection point of V_D and %VR. Thus, the Nominal 'Pi' has the best performance curve in terms of V_D and %VR compared with other configurations. In terms of P_{LOSS} in the line, all types of medium lines fluctuated. However, the Nominal 'T' and Nominal 'Pi' performance curves have the same characteristics on the last two trials and intend to be constant within the average of the highest and lowest value in the intersection point of the curve, whereas, the end condenser performance curve based on the last trial of P_{LOSS} tend to decrease as the lowest among their intersection points. Therefore, the End Condenser has the best curve in terms of P_{LOSS} as the value of capacitance increases. For transmission line efficiencies, their performance curves also fluctuated, but then, the Nominal 'T' and Nominal 'Pi' have the same characteristics, their efficiency tend to increase but did not go beyond the highest point of intersection on the curves. However, the efficiency of End Condenser as shown in the performance curve in the last trial, tend to increase higher than any of the intersection points on the curve. Hence as the capacitance is increased, the End Condenser has the best efficiency among the other types of medium transmission line.

Part II. Varying the Load

When the load is varied with increasing capacity, it has been observed that the End Condenser has the lowest voltage drop and yielded best performance in terms of efficiency among the three types of medium line configuration. The Nominal ‘T’ has the highest power loss in the line. So, the Nominal ‘Pi’ has the lowest performance among them. Based from the performance curves, the End Condenser has the best performance in terms of V_D, %VR and η_{TL}. Whereas, in terms of P_{LOSS}, the End Condenser and the Nominal ‘Pi’ configurations have the same characteristics.

In increasing the load impedance, the performance curves of the line show that all types of medium lines in terms of V_D and %VR have almost the same straight line inclined upward. However, the End Condenser has the best performance curve in terms of V_D and %VR because it has the lowest value on any intersection points at the last trial. In terms of P_{LOSS}, the End Condenser and the Nominal ‘Pi’ have the same behavior based on their two last trials which tend to be constant. However, the Nominal ‘Pi’ has the lowest value in watts, whereas the Nominal ‘T’, based on the last trial, tend to increase in great difference as the load is increased. Therefore, in terms of P_{LOSS}, the End Condenser and the Nominal ‘Pi’ have the same behavior. Based on test results, the researchers conclude that the End Condenser configuration yields the best performance in efficiency among the three types of medium transmission lines.

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Nomenclatures:

X_L	Inductive Reactance
X_C	Capacitive Reactance
P_{LOSS}	Power Loss
V_D	Voltage Drop
%VR	% Voltage Regulation
PF	Power Factor
η_{TL}	Transmission line Efficiency
I_{C1}	Charging Current 1
I_{C2}	Charging Current 2
I_C	Current through the capacitor
I_S	Current at the sending end
I_R	Current at the receiving end
P_S	Power at sending end
P_R	Power at receiving end
C	Capacitor
R	Resistor
f	frequency
f_S	Frequency at sending end
f_R	Frequency at receiving end
V_S	Voltage at sending end
V_R	Voltage at receiving end
V	Voltage
I	Current
Z	Load impedance
WS	Wattmeter at the sending end
WR	Wattmeter at the receiving end
AS	Ammeter at the sending end
AR	Ammeter at the receiving end
pfs	Power factor meter at the sending end
pfr	Power factor meter at the receiving end
fs	Frequency meter at the sending end
fr	Frequency meter at the receiving end
VS	Voltmeter at the sending end
VR	Voltmeter at the receiving end