# Study of The Electric Field Between Horizontal and Vertical Configuration Pole under 150 KV High Voltage Transmission Line (SUTT 150 KV)

Anak Agung Ngurah Amrita[1]

[1] Department of Electrical Engineering,
Faculty of Engineering
Udayana University
Bali – Indonesia
ngr_amrita@unud.ac.id

**Abstract** Distribution of electrical energy from a plant to a substation or from a substation to other substations usually uses a transmission line. In Bali, type of transmission line that is usually implemented is SUTT 150 kV. The magnitude of the applied voltage is an attempt to reduce power loss for long distance distribution. However, distributing electrical energy with increasing stress affects the increase of electric field around the transmission line. The negative impact of electricity distribution has been an environmental problem for PT. PLN (Persero), especially where there is conversion from an open area to be a residential. This problem has been the main reason for conducting this research. IRPA / INIRC recommendation states that exposure time is not limited to the electric field effect in work environment and public area including a residential area at frequency of 50/60 Hz is 5 kV/m. This recommendation is in accordance with SNI 04-6950-2003, on Threshold Limit Values Electric Field under SUTT and high-voltage wires. The first problem of this research is how large the intensity of the electric field between two poles of SUTT 150 kV with vertical and horizontal constructions which are built side by side? The second problem is what the characteristic of the electric field intensity between the two poles which are built side by side? From the analysis, it can be seen that the intensity of the electric field that occurs between the conductor of the vertical and horizontal pole configurations are still below the IRPA/INIRC and SNI 04-6950-2003 recommendation i.e. 1 up to 1.5 kV/m and at a distance of 18 meters to 25 meters there is an interaction of electric field intensity that occurs at these two configurations.

***Index Terms* — Electric Field Intensity, The Value of Threshold Electric Field, SUTT 150 kV, Vertical Configuration, Horizontal Configuration**

## I. INTRODUCTION

Distribution of electricity from plants to substations requires long transmission line, where it can increase power losses. One solution to overcome this problem is by increasing the voltage in transmission line to become high voltage of 150 kV or even more to become 500 kV. This solution is based on concept that by increasing voltage it causes electric current that flows in transmission line to become smaller, where therefore losses is also small.

Distribution of 150 kV high voltage or 500 kV ultra high voltage supplies negative impact for environment due to the construction of electric field around transmission line. This negative impact is an indirect effect from the electric field, which influences psychological aspects such as fear, environmental comfort like closing electromagnetic radiation, or effect caused by touching stuffs containing electricity. These facts have been environmental problems for PT. PLN, moreover when open area changes to become settlement. Transmission line that was built above open area like rice field is now above buildings.

IRPA/INIRC recommendation states that exposure time is not limited to the electric field effect in work environment and public area including residential area at frequency of 50/60 Hz is 5 kV/m. This recommendation is in accordance with SNI 04-6950-2003, on Threshold Limit Values Electric Field under High Voltage Transmission Line i.e.

"Saluran Udara Tegangan Tinggi" (SUTT) and Extra High Voltage Transmission Line i.e. "Saluran Udara Tegangan Ekstra Tinggi" (SUTET).

There are many studies in term of electric and magnetic field intensity. For instance, (Suwitno and Fri Murdiyah, 2010) studied intensity of electric and magnetic field threshod of SUTT 150 kV in transmission line that traverses Kampar and Pekanbaru regency. The results of their research state that for the magnetic and electric field intensity, they obtained result of 0,00009 Tesla and 70 V/m repectively, which are both still below threshold. Other schoolar, (Syafril Ramadan and Hendra Zulkarnain, 2013) examined electric field intensity under 150 kV transmission line between Titi Kuning Substation and Berastagi Substation. This researher also produced results below the defining threshold. Furthermore, there is also study about electric field intensity under 150 kV transmission line on vertical pole configuration. Study in 11 points conducted by (M.S. Ugustra, A.A.N.Amrita, and I.G.N. Janardana, 2014) shows result that the highest electric field occurs in point number 6 that is directly below the transmission line. The value is also below the electric field intensity threshold. After the study in vertical configuration, there is also reference that discusses horizontal configuration conducted by (I.P.H. Wahyudi, A.A.N.Amrita, W.G. Ariastina, 2014). In this study,7 points were examined, where the results show that the highest electric field intensity that is still below threshold, occur in points number 2 and 6, which are drectly below phase R and T of the transmission line. Other than these references there are also studies related to electric field intensity. (I.G.N. Adi Kurniawan, A.A.N.Amrita, I N. Budiastra, 2015) for instance. These people studied electric field intensity under 150 kV with horizontal configuration in settlement area. Results of this study is a recommendation for building elevation in some points that are traversed by the 150 kV line in order to maintain the electric field below the threshold. Other result of this study is that they do not recommend to build terraced houses in the cable arch of transmission line. The last reference stated here is study by (I.N.Y. Prayoga, A.A.N. Amrita, C.G.I.Partha, 2015) which studied electric field intensity under 150 kV with vertical configuration in settlement area. This study also recommends not to build terraced houses in the cable arch of transmission line.

Based on these studies, in this research we examined electric field intensity under SUTT 150 kV between poles of vertical and horizontal configurations. This topic arises due to the facts that the cange of open area to become settlement area to make many building positioned below the vertical and horizontal configuration in the same place.

## II. Research Methodology

Figure 1 shows the flowchart of this research.

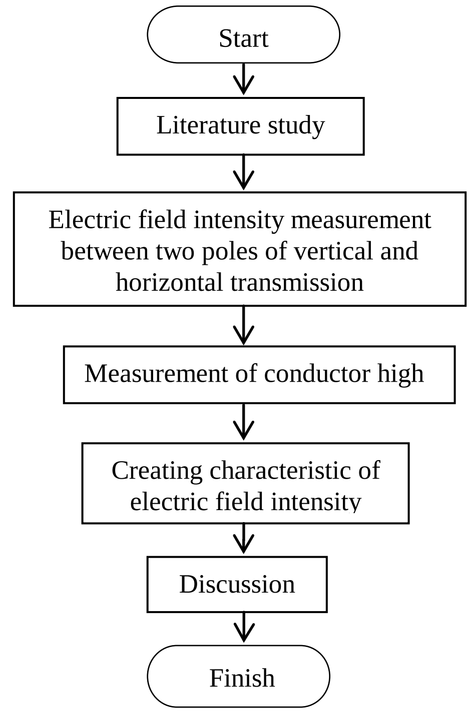


Fig. 1. Research Metodology Flow Chart

Location of this research as well as place for obtaining primary data is in 150 kV transmission line track between Sanur substation and Gianyar substation in three different location, that are: 1) Pantai Purnama street, Sukawati, Gianyar, in vertical pole number 119 – 120, and horizontal pole number 108 – 109; 2) Pantai Saba street, Blahbatuh, Gianyar, in vertical pole number 135 – 136 and horizontal pole number 125 – 126. These locations were chose due to some reasons, such as their shape that is flat, large, and open, which make measurement to become easier.

Measurement is done through two stages: 1) measurement of conductor high from vertical and horizontal poles by using klinometer, and 2) measurement of electric field by using AC Electric Field Meter.

## III. Results and Discussion

### *A. Results*

Table 1-3 shows results of conductor high measurement. Values in these tables are average values conducted by three peoples at the same time, repeated for two times, in different locations.

TABLE I
RESULTS OF CONDUCTOR HIGH MEASUREMENT AT LOCATION-1

| No. | Vertical Configuration Pole, 60 meters long | | | | |
|---|---|---|---|---|---|
| | Point of measurement | | The height of conductor in each phase | | |
| | Initial | Distance (m) | R (m) | S (m) | T (m) |
| 1 | A | 0 | 21.17 | 19.31 | 16.92 |
| 2 | B | 20 | 20.62 | 17.95 | 15.93 |
| 3 | C | 40 | 20.45 | 17.78 | 15.76 |
| 4 | D | 60 | 21.15 | 19.15 | 16.84 |
| 5 | E | + 20 (80) | 20.59 | 17.88 | 15.89 |
| 6 | F | + 28 (88) | 20.55 | 17.84 | 15.87 |

| No. | Horizontal Configuration Pole, 80 meters long | | |
|---|---|---|---|
| | Point of measurement | | The height of conductor in phase |
| | Initial | Distance (m) | R (m) |
| 1 | A | -8 | 12.48 |
| 2 | B | 12 | 12.22 |
| 3 | C | 32 | 11.53 |
| 4 | D | 52 | 11.79 |
| 5 | E | 72 | 12.45 |
| 6 | F | 80 | 12.75 |

TABLE II
RESULTS OF CONDUCTOR HIGH MEASUREMENT AT LOCATION-2

| No. | Vertical Configuration Pole, 80 meters long | | | | |
|---|---|---|---|---|---|
| | Point of measurement | | The height of conductor in each phase | | |
| | Initial | Distance (m) | R (m) | S (m) | T (m) |
| 1 | A | 0 | 22.15 | 19.52 | 17.15 |
| 2 | B | 20 | 20.93 | 18.16 | 16.16 |
| 3 | C | 40 | 19.66 | 17.27 | 15.23 |
| 4 | D | 60 | 20.78 | 18.03 | 16.04 |
| 5 | E | 80 | 21.90 | 19.40 | 17.03 |
| 6 | F | + 8 (88) | 21.09 | 18.63 | 16.62 |

| No. | Horizontal Configuration Pole, 80 meters long | | |
|---|---|---|---|
| | Point of measurement | | The height of conductor in phase |
| | Initial | Distance (m) | R (m) |
| 1 | A | -8 | 12.62 |
| 2 | B | 12 | 12.35 |
| 3 | C | 32 | 11.62 |
| 4 | D | 52 | 11.83 |
| 5 | E | 72 | 12.68 |
| 6 | F | 80 | 12.84 |

TABLE III
RESULTS OF CONDUCTOR HIGH MEASUREMENT AT LOCATION-3

| No. | Vertical Configuration Pole, 80 meters long | | | | |
|---|---|---|---|---|---|
| | Point of measurement | | The height of conductor in each phase | | |
| | Initial | Distance (m) | R (m) | S (m) | T (m) |
| 1 | A | -5 | 21.17 | 19.31 | 16.92 |
| 2 | B | 0 | 20.62 | 17.95 | 15.93 |
| 3 | C | 20 | 20.45 | 17.78 | 15.76 |
| 4 | D | 40 | 21.15 | 19.15 | 16.84 |
| 5 | E | 60 | 20.59 | 17.88 | 15.89 |
| 6 | F | 80 | 20.55 | 17.84 | 15.87 |

| No. | Horizontal Configuration Pole, 60 meters long | | |
|---|---|---|---|
| | Point of measurement | | The height of conductor in phase |
| | Initial | Distance (m) | R (m) |
| 1 | A | 0 | 12.65 |
| 2 | B | 5 | 12.45 |
| 3 | C | 25 | 11.82 |
| 4 | D | 45 | 12.17 |
| 5 | E | 60 | 12.40 |
| 6 | F | +25 (85) | 11.78 |

Results of electric field intensity measurements using AC Electric Field Meter in each location are shown in Tables 4-6 respectively.

TABLE IV
RESULTS OF ELECTRIC FIELD INTENSITY AT LOCATION-1

| Measurement point (m) | Electric field intensity (V/m) | | | | | |
|---|---|---|---|---|---|---|
| | A (0m) | B (20m) | C (40m) | D (60m) | E (80m) | F (88m) |
| 1 | 1513 | 1535 | 3118 | 0787 | 0681 | 1152 |
| 2 | 0193 | 1587 | 2724 | 1391 | 0098 | 0596 |
| 3 | 1022 | 1238 | 1762 | 1546 | 0563 | 0433 |
| 4 | 1973 | 0767 | 1427 | 1406 | 1617 | 0886 |
| 5 | 2621 | 0561 | 1851 | 2176 | 2434 | 1580 |
| 6 | 2963 | 1895 | 2676 | 3405 | 3194 | 2878 |
| 7 | 3170 | 2861 | 3575 | 4176 | 3534 | 3564 |
| 8 | 3336 | 3548 | 4264 | 4527 | 3942 | 3906 |
| 9 | 3635 | 3825 | 4282 | 4713 | 4426 | 4452 |
| 10 | 4283 | 4265 | 4424 | | | |

TABLE V
RESULTS OF ELECTRIC FIELD INTENSITY AT LOCATION-2

| Measurement point (m) | Electric field intensity (V/m) | | | | | |
|---|---|---|---|---|---|---|
| | A (0m) | B (20m) | C (40m) | D (60m) | E (80m) | F (88m) |
| 1 | 0433 | 1052 | 2124 | 1386 | 0356 | 0405 |
| 2 | 0195 | 0925 | 1771 | 1288 | 0115 | 0188 |
| 3 | 0476 | 0914 | 1452 | 1185 | 0537 | 0576 |
| 4 | 1774 | 1119 | 1064 | 1118 | 0975 | 1035 |
| 5 | 2483 | 1935 | 1778 | 2078 | 1513 | 1653 |
| 6 | 3215 | 2788 | 2745 | 3077 | 2043 | 2147 |
| 7 | 3814 | 3167 | 3354 | 3751 | 2456 | 2566 |
| 8 | 4063 | 4093 | 3915 | 4196 | 3014 | 3124 |
| 9 | 4315 | 4329 | 4335 | 4481 | 3547 | 3654 |

TABLE VI
RESULTS OF ELECTRIC FIELD INTENSITY AT LOCATION-3

| Measurement point (m) | Electric field intensity (V/m) | | | | | |
|---|---|---|---|---|---|---|
| | A (5m) | B (0m) | C (20m) | D (40m) | E (60m) | F (80m) |
| 1 | 0365 | 1278 | 1554 | 0456 | 0389 | 0566 |
| 2 | 0122 | 1035 | 1348 | 0157 | 0146 | 0227 |
| 3 | 0844 | 1002 | 0975 | 0942 | 0754 | 0843 |
| 4 | 1243 | 1273 | 0753 | 1278 | 1176 | 1244 |
| 5 | 2075 | 1977 | 1095 | 1654 | 1667 | 1734 |
| 6 | 2825 | 2821 | 2241 | 2257 | 2157 | 2231 |
| 7 | 3226 | 3284 | 2864 | 2832 | 2654 | 2768 |
| 8 | 3653 | 3625 | 3432 | 3421 | 3087 | 3012 |
| 9 | 3954 | 4078 | 3985 | 3842 | 3357 | 3365 |
| 10 | 4226 | 4485 | 4453 | 4134 | 3898 | 3823 |
| 11 | | | | 4453 | 4213 | 4278 |
| 12 | | | | | | 4334 |

*B. Discussion*

Figures 2-4 show results of electric field intensity measurement using AC Electric Field Meter in each location.

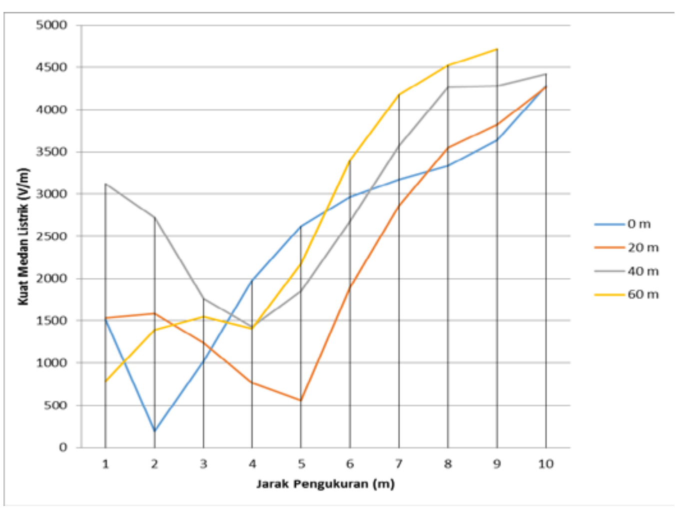


Fig. 2. Electric field intensity between two conductors of vertical and horizontal in location-1

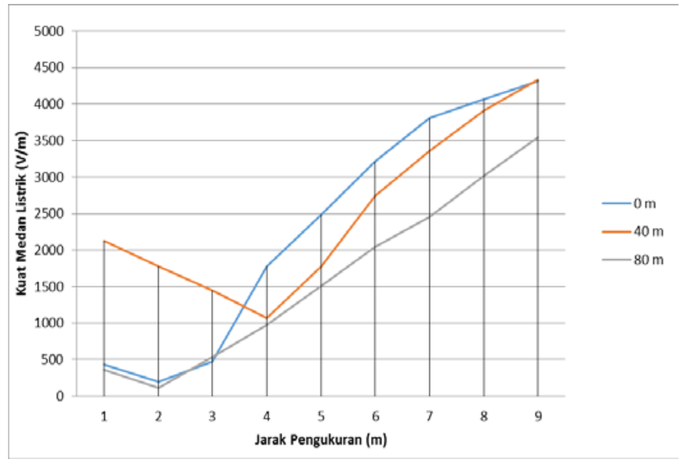


Fig. 3. Electric field intensity between two conductors of vertical and horizontal in location-2

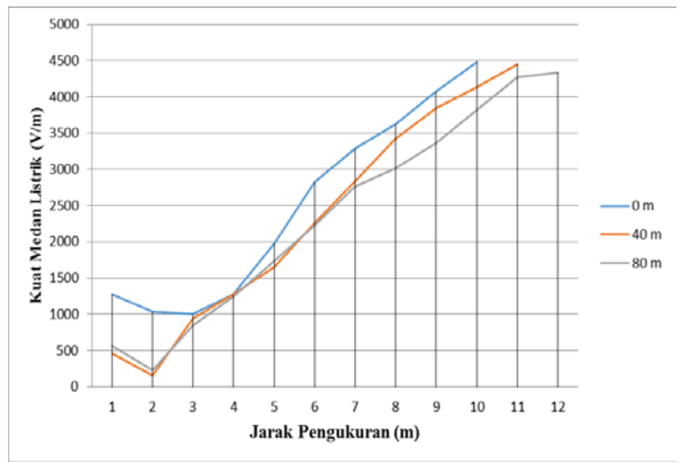


Fig. 4. Electric field intensity between two conductors of vertical and horizontal in location-3

These three figures show that there is interaction between electric field resulted by the two configurations even the are separated 18 meters up to 25 meters. Effect of electric field intensity resulted by horizontal configurations (right side of the figures) are more dominance from vertical configuration (left side of the figures).

Electric field intensity formed in the lowest point (cable arch of transmission line) between two configurations are still below threshold recommended by IRPA/INIRC or SNI 04-6950-2003, with values between 1 kV/m through 1.5 kV/m.

## IV. CONCLUSION

1) Electric field intensity occurred between conductors from vertical and horizontal poles are still below IRPA/INIRC and SNI 04-6950-2003 recommendations, which values are 1 to 1.5 kV/m.
2) In distance of 18 meters to 25 meters, there are still electric field interactions formed by the two configurations.

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