ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, November 2016

Experimental Investigation on the Effects of Ambient Temperature on Ionic Currents of HVDC Transmission Lines

K.Chaithanya Sai, K.A Aravind, Pradeep M Nirgudi, M. Prameela

PG Student, Department of EEE, B.V Raju Institute of Technology, Narsapur, Telangana, India

Central Power Research Institute, Hyderabad, India

Central Power Research Institute, Hyderabad, India

Professor, Department of EEE, B.V Raju Institute of Technology, Narsapur, India

ABSTRACT: HVDC transmission is more suitable for a long distance vast amount of power transmission. In HVDC transmission system corona is the concerned problem, due to ionization of ions on a conductor. Drifting of these ions results current flows at ground level. In view of this designing of HVDC transmission at UHV lines in hot weather conditions like India needs more attention before design the transmission line. This paper presents the experimental results on the effects of atmospheric temperatures for different line conductor configurations.

KEYWORDS: HVDC Overhead transmission line; Ionic curret;Ambient Temperature ; Wilson plate; DC nano ammeter.

I. INTRODUCTION

The HVDC transmission lines are extensively used for the vast amount of power transmission for long distances. HVDC transmission is reasonably priced and less electrical losses compared to HVAC transmission [1]. Corona on a transmission line is the considerable problem, which are critical in designing the UHVDC transmission lines. Corona is a type of partial discharge formed by the ionization of electrically charged conductors. Corona on a DC transmission line generates the ionic current environment under and near the HVDC transmission line [2]. The primary effect of corona discharge on a DC transmission line is a variation of ionic current flow at ground levels, not only the ionic current flow at ground levels, but it also accounts for, additional adverse effects of corona power loss, audible noises, and radio interface, and etc., hence it is essential to analyze the ionic current flow under the transmission lines as completely before designing the transmission lines.

In generally at ultra-high voltage levels, the dissimilarity of ionic current flow at ground levels under the DC transmission lines causes physiological effects to the living organisms under and near the transmission lines, it is essential to investigate UHVDC transmission lines at different weather conditions over a year before design the practical transmission lines [3][4]. It is observed from the literature ambient weather conditions are influencing ionic current flow at ground levels. This authenticates that enormous study of variations of ionic current flow at different atmospheric temperatures are essential before designing the HVDC transmission lines at UHV levels. To overcome this problem scale down models of experimental findings at actual atmosphere, that is, under outdoor conditions can provide significant support to evaluate the performance of ionic current flow at ground levels under the transmission lines. This paper presents the laboratory scale down experimental models carried out at outdoor conditions.

II. IONIC CURRENT MEASURMENT

HVDC transmission lines at corona discharged condition the couple of negative and positive ions is generated in the vicinity of line, which can flow on the conductor and towards the ground. To investigate the ionic current density on the ground, a collecting plate consistently called Wilson plate is used to capture ions which drift towards the ground [13]. The value of ion current can be calculated by the digital DC nano ammeter.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, November 2016

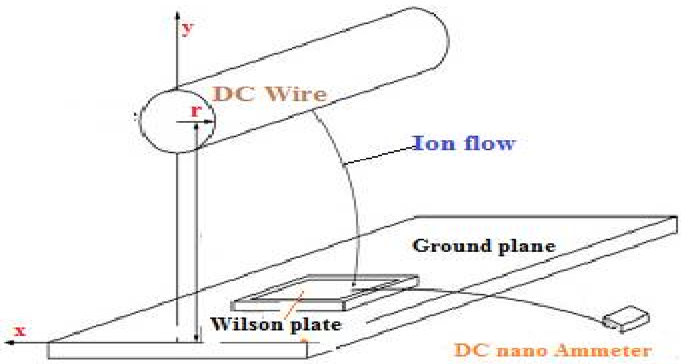

Fig.1. Schematic diagram of ionic current measurement system

III. WILSON PLATE

The magnitude of the ion-current density in the environs of DC power lines is implemented with a flat collection plate with DC nano ammeter succession [13]. The flat plate classically referred as Wilson plate, is to be found on the ground plane.

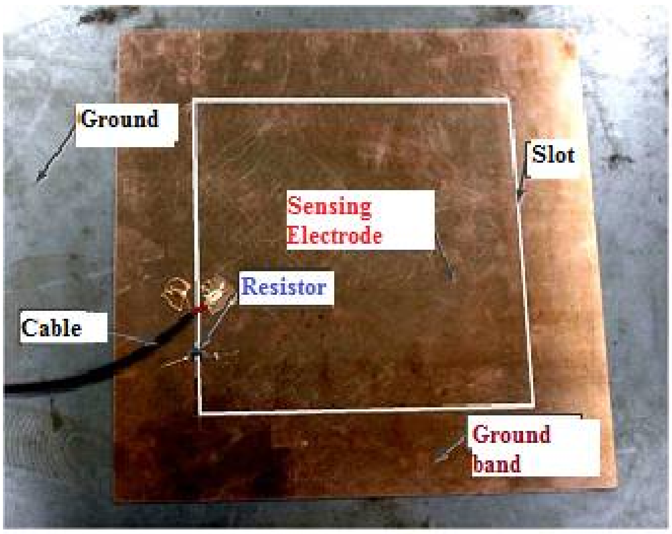

Fig.1. Schematic diagram of Wilson plate

IV. EXPERIMENTAL RESULTS

Ionic Current Density at Different Temperatures

Case: A

The unipolar DC line wire made up of copper material with a size of 1.219 mm and 130.5 cm high, are designed as shown in Fig.3. Wilson plate was put on the center of the test wire. The conductor was energized with positive polarity of DC voltage in the range of 30kv to 140kv. The experimental setup will be shown in figure 3. Here height between copper plate and ground plate is 10.5 cm and atmospheric pressure is 719mmhg. The measured ionic current density under the line at 41°c atmospheric temperature was listed in the Table.I.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, November 2016

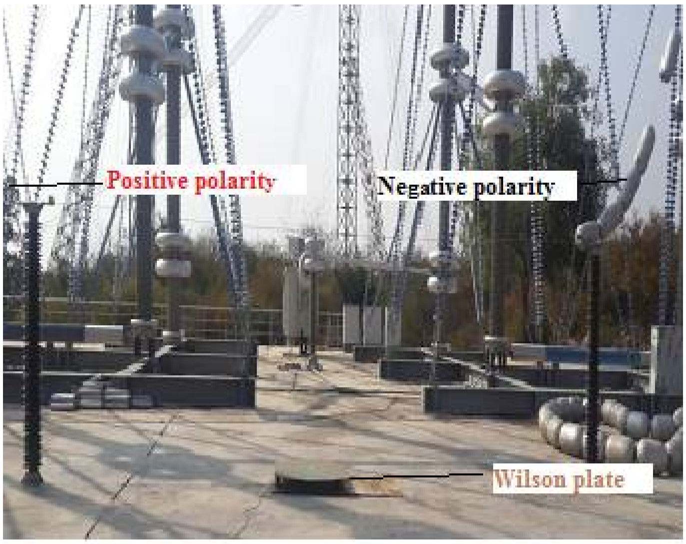

Fig.3. Experimental setup at CPRI

TABLE I. Magnitude of ionic current at 41°c temperature

Voltage (KV) +ve Polarity	Ionic Current magnitude (μA)
	41°c
30	0.0014
50	1.150
80	5.2
110	12.3
140	20.9

At 41°c temperature, different ionic currents are measured at various applied DC voltages as shown in Fig.4. The magnitude of ionic current is recorded at low wind velocity.

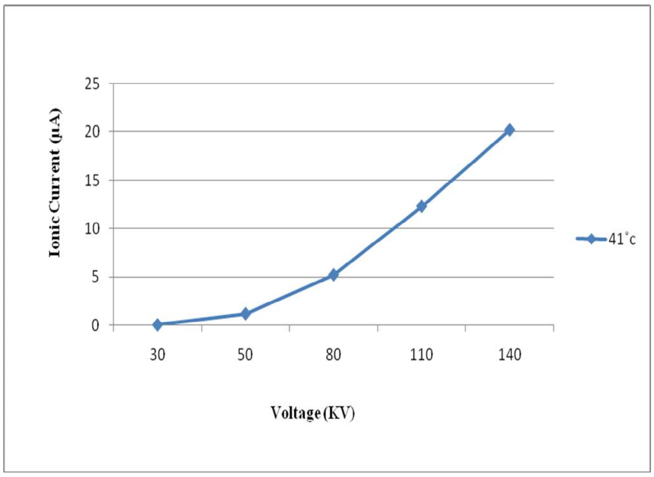

Fig.4. Variation of Ionic Current

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, November 2016

Case: B

For the same conductor configuration in Case A, The conductor was energized with negative polarity of the DC voltage with range of 30kv to 140kv. Here height between copper plate and ground plate is 10.5cm and atmospheric pressure is 721mmhg. The measured ionic current density under the line at 41°c atmospheric temperature was listed in the Table.II.

Table II. Magnitude of ionic current at 41°c temperature

Voltage (KV) -ve Polarity	Ionic Current magnitude (μA)
	41°c
30	0.592
50	2
80	6.34
110	13.5
140	22.5

At the certain temperature (i.e. 41°c) different ionic currents are measured at various applied DC voltages as shown in Fig.5. The magnitude of ionic current is recorded at negative polarity of the conductor.

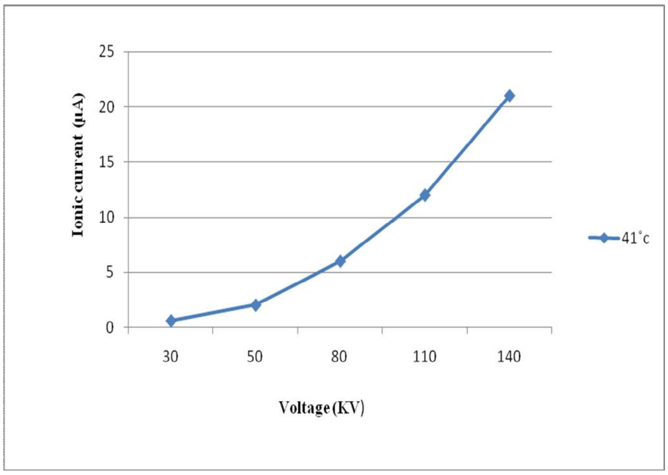

Fig. 5: Variation of ionic current

Case: C

The unipolar DC line wire made up of copper material with a size of 0.6 mm and 130.5 cm height are designed as shown in Fig.3. Wilson plate was put on the center of the test wire. The conductor was energized with positive polarity of DC voltage in the range of 30kv to 110kv. The experimental setup will be shown in Fig.3. The measured ionic current density under the line at 36°c atmospheric temperature was listed in the Table.III.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, November 2016

Voltage (KV) +ve Polarity	Ionic Current magnitude (µA)
	36°c
30	0.199
50	1.67
70	4.02
90	7.8
110	12.5

Table III. Magnitude of ionic current at 36°c temperature

The ionic current is recorded for 0.6mm size conductor. The ionic currents are measured with various applied DC voltages at 36°c temperature as shown in Fig.6.

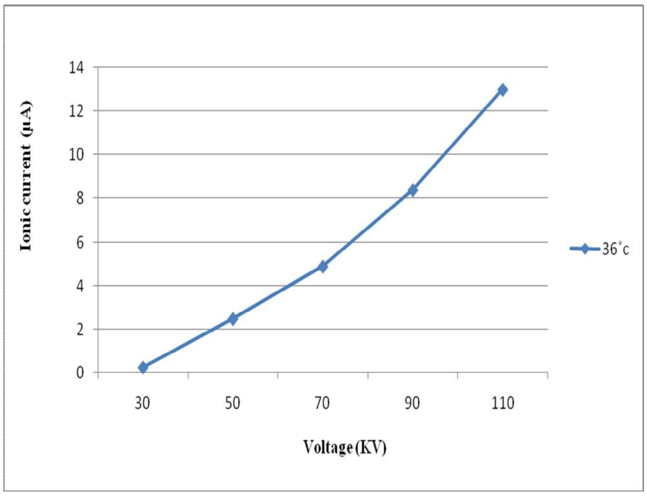

Fig. 6: Variation of ionic current

Case: D

For the same conductor configuration in Case C, The conductor was energized with negative polarity of the DC voltage with range of 30kv to 110kv. The measured ionic current density under the line at 36°c atmospheric temperature was listed in the Table .IV.

Table IV. Magnitude of ionic current at 36°c temperature

Voltage (KV) -ve Polarity	Ionic Current magnitude (µA)
	36°c
30	0.199
50	1.67
70	4.02
90	7.8
110	12.5

The ionic current is recorded for 0.6mm size conductor. The ionic currents are measured with various applied DC voltages at 36°c temperature shown in Fig.7.The magnitude of ionic current listed at low wind velocity condition.

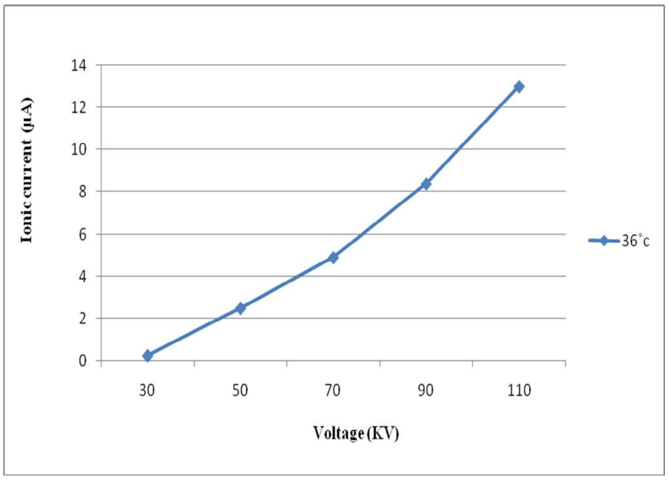

Fig. 7: Variation of ionic current

V. CONCLUSION

The experimental investigation on different HVDC line conductors by various experimental setups at outdoor conductor was conducted.

1. It is observed that, the ionic currents are higher for small conductor size at low ambient temperatures.
2. The ionic currents are lower for large conductor size at higher ambient temperatures.

VI. ACKNOWLEDGMENT

The authors pleasure to thank officers and Technicians of CPRI, India for giving permission to conduct experiments and promoting to publish this paper.

REFERENCES

[1] Zhaonan Luo, "Calculation of the 3-D Ionized Field Under HVDC Transmission Lines" IEEE TRANSACTIONS ON MAGNETICS, VOL. 47, NO. 5, MAY 2011.

[2] P.Sarma Maruvada, "Influence of Ambient Electric Fieldon the Corona Performance of HVDC transmission liines," IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 29, NO. 2, APRIL 2014.

[3] P.Sarma Maruvada, "Electric Field and Ion Current Environment of HVdc Transmission Lines: Comparison Of Calculations and Measurements," IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 27, NO. 1, JANUARY 2012.

[4] Yongzan Zhen, Xiang Cui, *Senior Member, IEEE*, Tiebing Lu, Xuebao Li, Chao Fang, and Xiangxian Zhou, "3-D Finite-Element Method for Calculating the Ionized Electric Field and the Ion Current of the Human Body Model Under the UHVDC Lines" IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 28, NO. 2, APRIL 2013.

[5] Yongzan Zhen, Xiang Cui, Tiebing Lu, Xiangxian Zhou, and Zhaonan Luo," High Efficiency FEM Calculation of the Ionized Field Under HVDCTransmission Lines.

[6] Jie Liu, Jun Zou, Jihuan Tian, and Jiansheng Yuan," Analysis of Electric Field, Ion Flow Density, and Corona Loss of Same-Tower Double-Circuit HVDC Lines Using Improved FEM" IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 24, NO. 1, JANUARY 2009

[7] Zhaonan Luo , Xiang Cui , Jiayu Lu "Analysis of Ionized Field under HVDC Transmission Lines with Buildings Nearby" 2010 Asia-Pacific International Symposium on Electromagnetic Compatibility, April 12 - 16, 2010, Beijing, China.

[8] Yongzan Zhen, Xiang Cui, *Senior Member, IEEE*, Tiebing Lu, Xuebao Li, Chao Fang, and Xiangxian Zhou," 3-D Finite-Element Method for Calculating the Ionized Electric Field and the Ion Current of the Human Body Model Under the UHVDC Lines" IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 28, NO. 2, APRIL 2013.

[9] Zhaonan Luo, "Calculation of the 3-D Ionized Field Under HVDC Transmission Lines"IEEE TRANSACTIONS ON MAGNETICS, VOL. 47, NO. 5, MAY 2011.

[10] Bo Zhang, *Member, IEEE*, Han Yin, Jinliang He, "Computation of Ion-Flow Field Near the Metal Board House Under the HVDC Bipolar Transmission Line" IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 28, NO. 2, APRIL 2013.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 8, November 2016

[11] N.M. Ijumba , M.J. Lekganyane , "COMPARATIVE STUDIES OF AC AND DC CORONA POWER LOSSES IN AN INDOOR CORONA CAGE" Proceedings of the 16th International Symposium on High Voltage Engineering 2009 SAIEE, Innes House, Johannesburg.

[12] Chao Fang, Xiang Cui, *Senior Member, IEEE*, Xiangxian Zhou, *Student Member, IEEE*, Tiebing Lu, "Impact Factors in Measurements of Ion-Current Density Produced by High-Voltage DC Wire's Corona" IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 28, NO. 3, JULY 2013.

[13] Xuebao Li, Xiang Cui, *Senior Member, IEEE,* "The Ionized Fields and the Ion Current on a Human Model Under 800-kV HVDC Transmission Lines" IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 27, NO. 4, OCTOBER 2012.

[14] P.Sarma Maruvada," Electric Field and Ion Current Environment of HVdc Transmission Lines: Comparison Of Calculations and Measurements," IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 27, NO. 1, JANUARY 2012.