

51. IWK
Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium



PROCEEDINGS

11-15 September 2006

**FACULTY OF ELECTRICAL ENGINEERING
AND INFORMATION SCIENCE**



**INFORMATION TECHNOLOGY AND
ELECTRICAL ENGINEERING -
DEVICES AND SYSTEMS,
MATERIALS AND TECHNOLOGIES
FOR THE FUTURE**

Startseite / Index:

<http://www.db-thueringen.de/servlets/DocumentServlet?id=12391>

Impressum

- Herausgeber: Der Rektor der Technischen Universität Ilmenau
Univ.-Prof. Dr. rer. nat. habil. Peter Scharff
- Redaktion: Referat Marketing und Studentische
Angelegenheiten
Andrea Schneider
- Fakultät für Elektrotechnik und Informationstechnik
Susanne Jakob
Dipl.-Ing. Helge Drumm
- Redaktionsschluss: 07. Juli 2006
- Technische Realisierung (CD-Rom-Ausgabe):
Institut für Medientechnik an der TU Ilmenau
Dipl.-Ing. Christian Weigel
Dipl.-Ing. Marco Albrecht
Dipl.-Ing. Helge Drumm
- Technische Realisierung (Online-Ausgabe):
Universitätsbibliothek Ilmenau
[ilmedia](#)
Postfach 10 05 65
98684 Ilmenau
- Verlag:  Verlag ISLE, Betriebsstätte des ISLE e.V.
Werner-von-Siemens-Str. 16
98693 Ilmenau

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ISBN (Druckausgabe): 3-938843-15-2
ISBN (CD-Rom-Ausgabe): 3-938843-16-0

Startseite / Index:

<http://www.db-thueringen.de/servlets/DocumentServlet?id=12391>

Field Distribution and Effective Height of Lightning Protection Rod with Horizontal Circular Loop – Full Model

Saša S. ILIĆ and Slavoljub R. ALEKSIĆ

1. INTRODUCTION

During a sunny summer day atmospheric electric field strength is in our region around 150 V/m , increasing during a thunderstorm till enormous values of around $5 \text{ kV/m} \div 10 \text{ kV/m}$. Such an atmospheric field is practically constant in time and almost homogeneous at long distances from the earth surface. Existing objects and buildings perturb the atmospheric field, so the field distribution in urban regions is non-homogeneous and very complex.

The atmospheric field distribution around the lightning protection rod with circular loop (Fig. 1) will be presented in this paper. Based on obtained results it is possible to determine the strength of resulting electric field in the surroundings of an isolated lightning protection rod with horizontal circular loop and to construct equipotential and equienergetic contours. It is also possible to determine the effective height of the lightning protection rod installed at earth surface and to investigate the influence of the volume and shape on effective height of lightning protection rod with horizontal loop [1]. These investigations are significant because the vertical rod in galvanic connection with horizontal loop has become the Serbian standard of lightning protection, JUS N. B4. 811. The theoretical basis of vertical rod with horizontal loop as lightning protection system has been for the first time presented in 1988 at lightning protection conference in Graz [1]. At the next conference on lightning protection, in 1992, in Berlin [2], the group of Japanese explorers has experimentally confirmed the mentioned theoretical results. The experimental results will be presented here too. In papers published up to now [3-13], all the parts of lightning protection rod with horizontal circular loop haven't been considered, that are otherwise used for fixing this lightning rod.

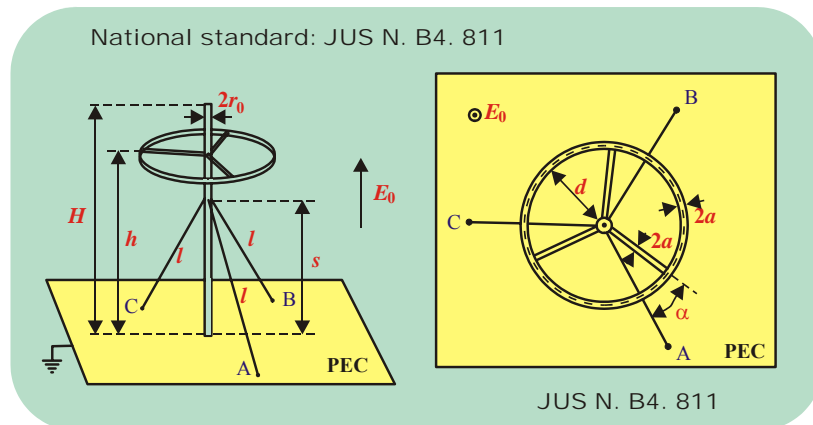


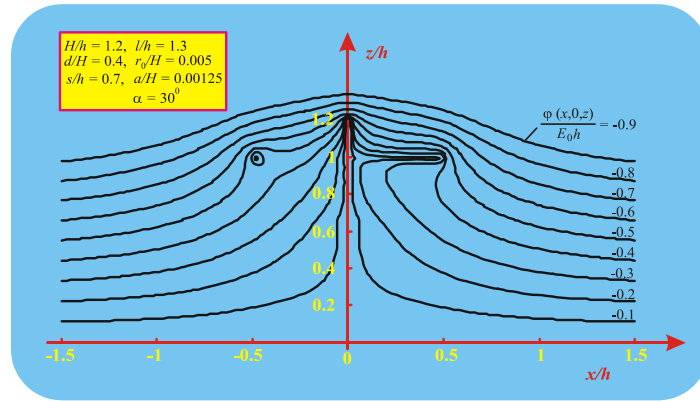
Fig. 1. Lightning protection rod with horizontal circular loop (JUS N. B4. 811).

2. THEORETICAL APPROACH

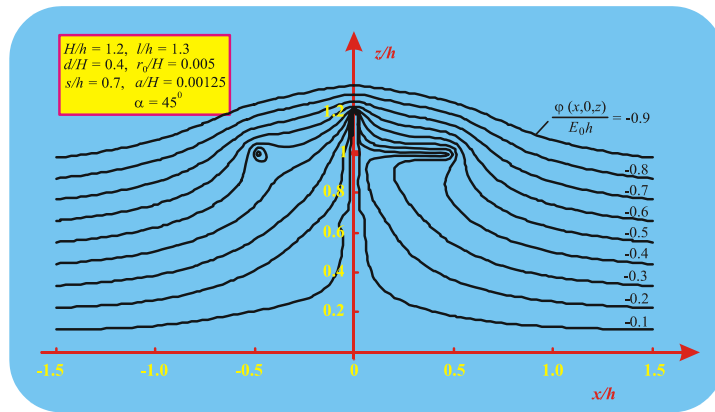
In order to determine electric field and potential distribution in the surroundings of the lightning protection rod with horizontal circular loop in atmospheric electric field, point matching method and method of segments are used. So the whole system is replaced by point equivalent unknown charges with position in centres of small segments. The upper rod basis is replaced by small spherical equivalent electrode having radius $a_e = 2r_0/\pi$, where r_0 is radius of lightning protection rod. Finally, using image theorem, the potential in the field point $M(x, y, z)$ can be given in the following form

$$\varphi = -E_0 z + \sum_{n=1}^N \frac{Q_n}{4\pi\epsilon_0} \left(\frac{1}{\sqrt{(x-x_n)^2 + (y-y_n)^2 + (z-z_n)^2}} - \frac{1}{\sqrt{(x-x_n)^2 + (y-y_n)^2 + (z+z_n)^2}} \right) \quad (1)$$

where:



b)



c)

Fig. 3. Field distribution near lightning protection rod (JUS N. B4. 811) versus different parameter α .

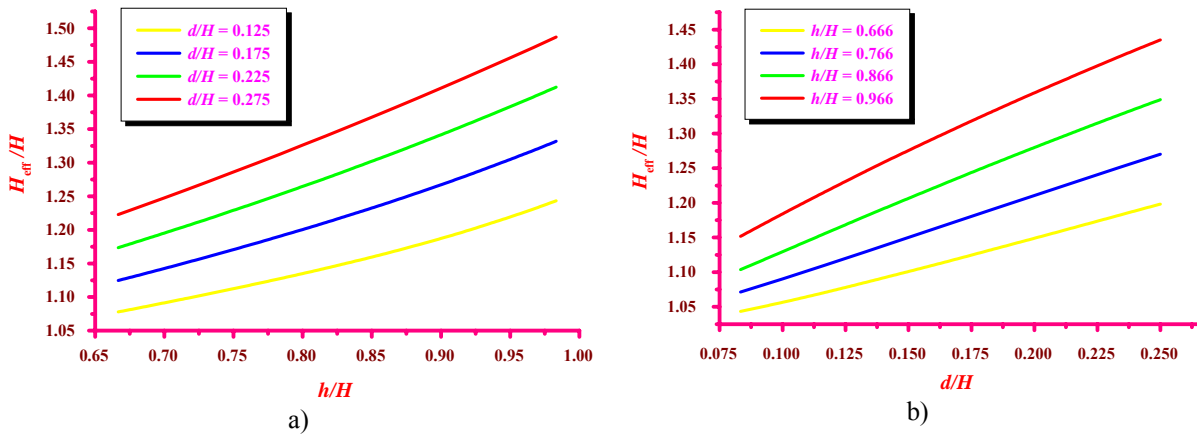


Fig. 4. Effective height of lightning protection rod (JUS N. B4. 811) versus parameters h/H and d/H .

4. CONCLUSION

Theoretical research has a numerical background and the results for electric field distribution and effective height are presented graphically. Effective height for real dimensions of lightning protection rod with horizontal circular loop has value $H_{\text{eff}} = 1.3H$. Effective height is one very important parameter for defining protection zone versus protection level of proposed lightning protection rod. The rod is tested in high voltage laboratory (Japan), and experimental results for effective height have very good agreement with theoretically obtained results.



Fig. 5. Photos of installed lightning protection rod (JUS N. B4. 811).

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