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# Lightning Surge Damage in PoE Ethernet Links: A Boyolali Tower Case Study

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**A B S T R A CT**

Lightning surge damage in hybrid power and communication infrastructures remains a critical issue in tropical regions with high lightning activity. This case study investigates network equipment failure following a thunderstorm-induced power outage exceeding 24 hours in Boyolali, Central Java, Indonesia. The system comprises a 28 m communication tower connected to a server building via a 15 m outdoor unshielded twisted-pair (UTP) Ethernet cable utilizing Power-over-Ethernet (PoE). The tower employs a dedicated lightning-protection grounding system, while the building uses a separate electrical grounding system separated by approximately 10 m and left unbonded. Post-incident inspection revealed that four networking devices were damaged: one PoE injector and one MikroTik CRS326 switch at the tower site, plus one MikroTik CRS326 and one D-Link DGS-1100-24 switch at the server building. The Dell PowerEdge R360 server remained operational after a manual restart. Failure analysis indicates that the damage resulted from surge propagation caused by ground potential rise (GPR) at the tower grounding system. The unbonded grounding systems and the conductive copper PoE link provided a low-impedance path for transient currents.
This study highlights the importance of coordinated grounding, surge protective devices (SPDs), and the preference for optical fiber links in hybrid infrastructures. The findings offer practical insights for enhancing lightning protection in tropical communication systems.

**Keywords**: lightning surge, ground potential rise, PoE, Ethernet, communication tower

## 1. Introduction

Lightning is one of the most common natural sources of electrical disturbances, affecting power systems and electronic equipment. Lightning discharges generate high transient currents and electromagnetic fields, which can induce overvoltages in nearby electrical and communication networks. These transient events may propagate through interconnected infrastructure, and damage sensitive electronic devices [1], [2], [3].

In tropical regions such as Indonesia, lightning activity is frequent, particularly during the rainy season [4], [5]. Consequently, electrical and communication infrastructures in these areas face elevated risks. Communication towers, being tall and exposed structures, are especially vulnerable [4], [6].

Modern communication systems frequently integrate power and data networks. Servers, switches, and other equipment are often interconnected using copper cables, including Ethernet links that may also carry electrical power via Power-over-Ethernet (PoE) technology. While this integration simplifies deployment, it can create additional conductive paths for surge energy during lightning events [7], [8].

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Lightning-induced disturbances can affect interconnected systems through direct surge injection, electromagnetic coupling, or ground potential rise (GPR). GPR occurs when lightning current enters a grounding system, temporarily elevating its electrical potential [9]. When separate or inadequately bonded grounding systems exist, significant voltage differences can develop [10], [11]. Conductive links between these systems then allow surge currents to flow in an attempt to equalize potentials [7], [12].

Previous studies have demonstrated that copper communication cables, such as Ethernet links, can serve as pathways for transient currents under such conditions [7], [12], [13]. Networking devices, particularly switches and routers, are highly susceptible due to their direct interface connections [13], [14]. The use of PoE further increases electrical coupling between power and communication systems, potentially facilitating surge propagation [7], [13], [15]. International standards such as IEC 61000-4-5 provide testing methods to evaluate equipment immunity to such surges [16], [17].

Although extensive research exists on lightning effects and surge propagation, detailed field case studies of actual damage in real-world communication infrastructure—especially in tropical regions such as Indonesia—remain limited [12], [18]. Such case studies are essential for bridging theoretical mechanisms with practical installations in high-lightning-activity areas [19].

This paper presents a field case study of lightning-induced surge damage to PoE-based Ethernet equipment in a hybrid power and communication infrastructure located in Boyolali, Central Java, Indonesia. The investigated system comprises a 28 m communication tower connected to a server building through a 15 m outdoor UTP Ethernet cable utilizing Power-over-Ethernet technology, with separate and unbonded grounding systems separated by approximately 10 m. Following a thunderstorm and a prolonged power outage exceeding 24 hours, four networking devices were damaged while the main server remained operational after a manual restart.

The study contributes to the existing literature by (1) documenting a real-world failure case in a tropical high-lightning-activity region, (2) providing quantitative estimation of ground potential rise (GPR) based on typical Indonesian lightning parameters and national standards, and (3) offering practical mitigation recommendations tailored to hybrid tower installations commonly found in Indonesia. These findings emphasize the critical role of coordinated grounding and communication media selection in preventing surge propagation through PoE links.

## 2. Method

### 2.1. Site and Infrastructure Description

The study examined a hybrid communication infrastructure consisting of a 28 m communication tower and a nearby server building in Boyolali, Central Java. The tower supports various networking equipment for communication services, while the server building houses computing systems and network devices.

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Fig. 1. Communication tower installation at the study site in Boyolali, Central Java, showing the tower structure and associated networking equipment at the base.

The tower and server building are interconnected by a wired Ethernet link, forming a hybrid system that integrates electrical power distribution and data communication. Such systems are known to be susceptible to lightning-induced disturbances [20]. Electrical power is supplied from the utility grid, while data communication is implemented using copper Ethernet cabling.

A simplified schematic of the infrastructure, including power distribution, network connections, and grounding arrangement, is presented in Fig. 2.

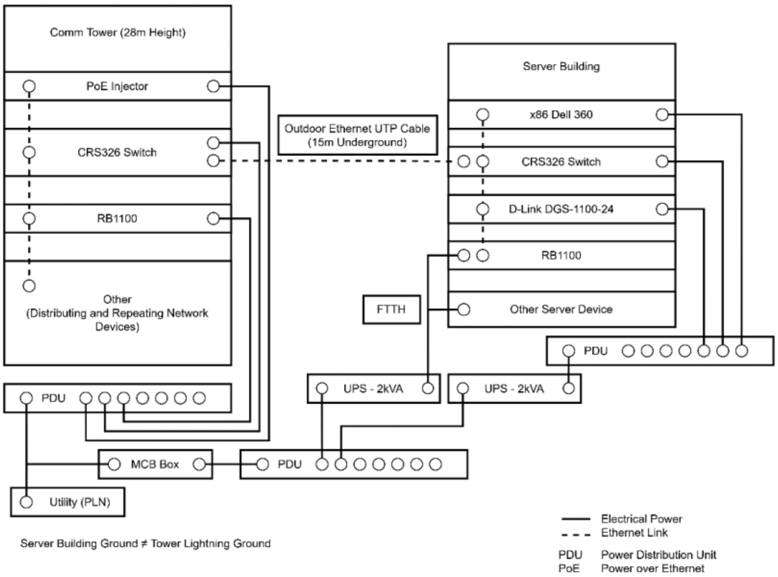


Fig. 2. Schematic diagram of the hybrid electrical and network infrastructure connecting a 28 m communication tower to the server building via a 15 m underground UTP Ethernet link with Power-over-Ethernet (PoE). The tower lightning-protection grounding system is separate from the building electrical grounding system.

### 2.2. Power Supply Configuration

Electrical power is supplied by the public utility (Perusahaan Listrik Negara – PLN) and distributed through the building electrical panel to the server and networking equipment. To ensure

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continuity during outages, the installation includes two uninterruptible power supply (UPS) units, each with a capacity of approximately 2 kVA, both located in the server building.

One UPS unit powers the server system and the networking equipment connected to the tower, while the second supports the fiber-to-the-home (FTTH) network. Power from the UPS units is further distributed through power distribution units (PDUs) inside the server room.

Fig. 3. Server-side rack configuration, showing network switches, servers, and interconnections within the indoor environment.

### 2.3. Network Configuration

The network infrastructure comprises several switching and routing devices located at both the server building and the tower site. The server building contains a Dell PowerEdge R360 server as the primary computing system, along with a D-Link DGS-1100-24 switch, a MikroTik CRS326 switch, and a MikroTik RB1100 router. These devices handle switching, routing, and communication with external networks.

At the tower site, a MikroTik CRS326 switch is connected to a Power-over-Ethernet (PoE) injector that supplies power to tower equipment. The specifications and post-incident status of the key networking devices are summarized in Table 1.

Table 1. List of key networking devices and post-incident status

| Device | Model | Location | Function | Post-Incident Status |
|---|---|---|---|---|
| PoE Injector | Not specified | Tower base | Supplies PoE to tower equipment | Damaged |
| Network Switch | MikroTik CRS326 | Tower site | Switching and PoE distribution | Damaged |

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| Device | Model | Location | Function | Post-Incident Status |
|---|---|---|---|---|
| Network Switch | MikroTik CRS326 | Server building | Core network switching | Damaged |
| Network Switch | D-Link DGS-1100-24 | Server building | Server and network connectivity | Damaged |
| Server | Dell PowerEdge R360 | Server building | Primary computing and data processing | Operational (manual restart) |
| Router | MikroTik RB1100 | Server building | Routing and WAN connectivity | Operational |

### 2.4. Interconnection Between Tower and Server Building

The communication link between the tower and the server building uses a 15 m unshielded twisted-pair (UTP) copper Ethernet cable installed outdoors through an underground conduit. In addition to data transmission, the system employs Power-over-Ethernet (PoE) technology, with the PoE injector located at the tower base supplying both data and power over the same cable.

### 2.5. Grounding Configuration

The communication tower is equipped with a dedicated lightning-protection grounding system designed to safely dissipate lightning currents. The server building uses a separate electrical grounding system tied to the building power installation. These two grounding systems are not bonded and are separated by approximately 10 m. The configuration of the two grounding systems is summarized in Table 2.

Table 2. Grounding system configuration

| Parameter | Tower Grounding System | Building Grounding System |
|---|---|---|
| Type | Dedicated lightning protection system | Electrical building grounding |
| Bonding status | Not bonded with building ground | Not bonded with tower ground |
| Approximate separation | 10m | - |
| Purpose | Dissipation of lightning current | Safety grounding for power system |
| Material/electrode | Copper rod/counterpoise (standard tower) | Building electrical panel ground |

### 2.6. Data Collection

Data were collected through post-incident inspection, direct observation of the infrastructure, and interviews with the site operator. Photographic documentation of the tower site, server room, electrical installation, and damaged equipment provided additional supporting evidence for the analysis.

## 3. Result and Discussion

### 3.1. Incident Description

On the day of the incident, Boyolali, Central Java, experienced a thunderstorm with heavy rainfall and visible lightning activity. During this event, a disturbance in the PLN electrical distribution network caused a power outage lasting more than 24 hours. The blackout occurred approximately between 14:00 and 15:00 local time.

At the time of the outage, the server infrastructure and networking equipment were operating normally. The UPS units in the server building activated and issued alarm signals indicating loss of

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input power. Equipment at the tower site lost power immediately, as no local backup was available. After electrical service was restored, communication between the server building and the tower could not be re-established.

### 3.2. Damage Observation

Following power restoration, an inspection revealed that several network devices had become non-operational. The damaged equipment included:

- One PoE injector at the tower base
- One MikroTik CRS326 switch at the tower site
- One MikroTik CRS326 switch at the server building
- One D-Link DGS-1100-24 switch connected to the server system

These devices could not be restored to working condition.

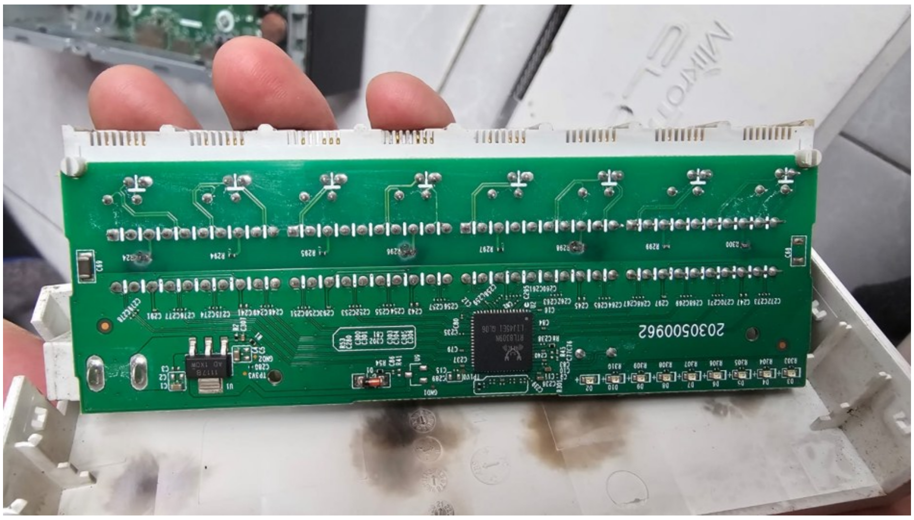


Fig. 4. Internal PCB of a damaged network device, showing localized thermal damage near the input circuitry, indicating surge propagation into the device and subsequent component failure.

The internal damage observed on the PCB confirms that surge energy propagated beyond the external interfaces and affected internal electronic components.


Fig. 5. Internal view of the MikroTik CRS326 switch after the incident. Although no visible burn marks are present, the device failed to operate, indicating internal damage caused by lightning-induced overvoltage.

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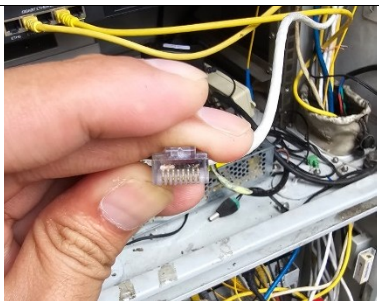

Fig. 6. Damaged RJ45 connector at the tower site, showing burn marks on the contact pins and confirming lightning-induced surge propagation through the Ethernet cable.

In contrast, the Dell PowerEdge R360 server did not suffer permanent hardware damage, although it required a manual restart after power restoration.

Fig. 7. Uninterruptible Power Supply (UPS) unit used in the system. The unit exhibited no visible physical damage but required a manual restart after the incident.

Uninterruptible Power Supply (UPS) unit used in the system. The unit showed no visible physical damage but required a manual restart after the incident. Representative images of the infrastructure and damaged equipment are shown in Figs. 2–7.

### 3.3. Failure Mechanism Analysis

The observed damage pattern can be explained by the interaction between the lightning event, the separate grounding systems, and the conductive copper Ethernet link. During the thunderstorm, lightning current was most likely injected into the communication tower, which is equipped with a dedicated lightning-protection grounding system. This injection causes a rapid rise in local ground potential, known as ground potential rise (GPR) [9], [10].

A significant voltage difference develops between the two grounding reference because the tower grounding system and the server building grounding system are not bonded and are separated by approximately 10m. The 15 m outdoor UTP Ethernet cable, which carries both data and Power-over-Ethernet (PoE) power, provides a low-impedance conductive path between these two points. Surge currents therefore flow through the Ethernet cable in an attempt to equalize the potential difference, damaging the network equipment at both ends.

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### 3.3.1. Quantitative Estimation of Ground Potential Rise

A rough estimation of the GPR can be performed using the simplified formula:

$$V_{GPR} \approx I_{peak} \times R_g \tag{1}$$

Where $I_{peak}$ is the lightning peak current and $R_g$ is the grounding resistance of the tower. Typical values for a lightning stroke in tropical regions range from 10-50 kA [4], while the tower grounding resistance is commonly between 5-10 Ω according to Indonesian national standards [21], [22]. Assuming a moderate stroke of 30 kA and $R_g = 5\ \Omega$, the estimated GPR reaches approximately 150 kV. Even a smaller current of 10 kA would still produce a GPR of 50 kV. This transient voltage is more than sufficient to exceed the surge immunity rating of standard Ethernet ports and PoE equipment (typically 1-2 kV according to IEC 61000-4-5).

A simplified illustration of the surge propagation path, including the estimated GPR and cable parameters, is shown in Fig. 8.

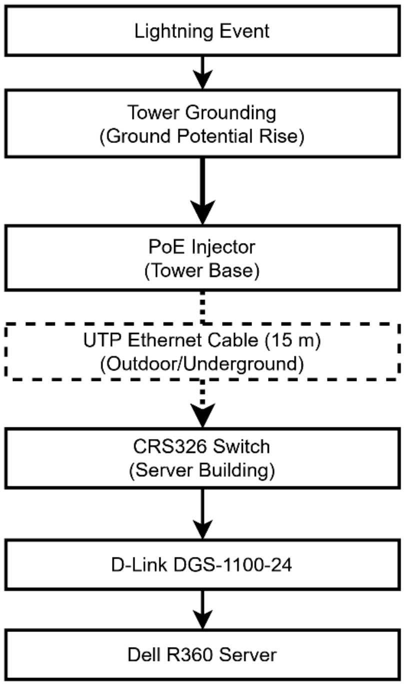


Fig. 8. Simplified illustration of the plausible surge propagation path. The tower grounding system experiences an estimated GPR of approximately 150 kV (for $I_{peak} = 30kA, R_g = 5\Omega$). The 15 m UTP Ethernet cable with PoE connects the tower site to the server building, whose grounding system remains at local ground potential.

This mechanism is consistent with the observed damage: PoE-related equipment and both MikroTik CRS326 switches were destroyed, while the server's Ethernet interface survived because the intermediate networking devices absorbed most of the surge energy.

### 3.4. Discussion

The results of this case study demonstrate the vulnerability of hybrid power and communication infrastructures to lightning-induced surges, particularly in high-lightning-activity regions such as Central Java, Indonesia. The investigated system exhibited several risk factors: a 28 m elevated communication tower, separate and unbonded grounding systems separated by 10 m, a 15 m outdoor copper UTP Ethernet link, and the use of Power-over-Ethernet (PoE) technology. These elements

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collectively created a low-impedance path for surge currents triggered by ground potential rise (GPR) at the tower grounding system.

This failure mechanism aligns with findings from previous studies on surge propagation through copper communication cables in installations with multiple grounding references [7], [12], [13], [23]. For instance, similar damage patterns involving PoE equipment and Ethernet switches have been reported in telecommunication tower sites in tropical regions [24], [25]. The current case provides additional field evidence from an Indonesian installation, where the combination of prolonged power outage (>24 hours) and subsequent restoration likely exacerbated the transient stress on the network devices.

### 3.4.1. Limitations of the Study

This study is based on post-incident visual inspection, operator interviews, and photographic evidence. Direct surge measurements, grounding resistance values, or waveform recordings from the event were not available. Therefore, the proposed GPR mechanism remains an observational estimation rather than a fully instrumented validation. Future studies could benefit from installing surge recording devices and pre-event grounding measurements.

Recent studies in Indonesia also confirm the importance of complying with national lightning protection standards to prevent similar failures in communication infrastructure [26], [27], [28].

The absence of dedicated surge protection in the tower cabinet, as shown in Fig. 9, further contributed to the susceptibility of the system to incoming transients.

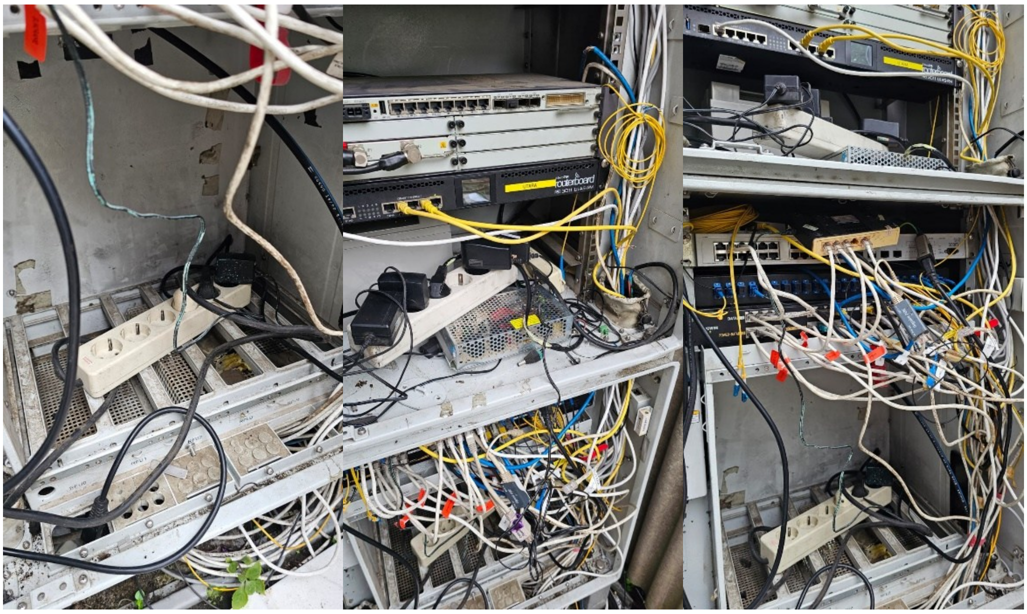

Fig. 9. Power distribution inside the tower cabinet using a standard power strip without dedicated surge protective devices (SPDs). This configuration increases vulnerability to lightning-induced transients.

To reduce the risk of similar incidents, several practical mitigation measures are recommended. These are summarized in Table 3, including estimated costs (approximate, in USD for a typical small-scale Indonesian installation) and effectiveness levels.

Table 3. Recommended mitigation measures for Hybrid Communication Tower and Server

| Mitigation Strategy | Description | Estimated Cost (USD) | Effectiveness | Reference |
|---|---|---|---|---|
| Equipotential bonding | Direct bonding of tower and building grounding systems using 16-25 mm² copper conductor | 150-300 | High | [10], [11], [21] |

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| Mitigation Strategy | Description | Estimated Cost (USD) | Effectiveness | Reference |
|---|---|---|---|---|
| Surge protective devices (SPDs) | Installation of Type 2 SPDs on PoE lines and Ethernet ports at both ends | 80-200 | High | [8], [17] |
| Optical fiber conversion | Replace copper UTP with fiber optic link + media converters | 250-450 | Very high | [23], [29] |
| Coordinated grounding + SPD | Combine bonding with SPDs and surge-rated PoE injectors | 300-500 | Very high | [25], [26], [30] |
| Shielded cable + proper routing | Use STP cable with correct shielding termination and separation from power lines | 100-250 | Medium | [13], [15], [22] |

These measures are technically feasible and cost-effective for most Indonesian telecom operators and small-scale server installations. Implementing optical fiber links, in particular, would eliminate the conductive path entirely and is strongly recommended as the most reliable long-term solution.

The findings underscore the need for better coordination between communication tower designers, network engineers, and power utility providers (PLN) in Indonesia to adopt standardized lightning protection practices.

## 4. Conclusion

This case study documented lightning-induced surge damage to networking equipment in a hybrid power and communication infrastructure in Boyolali, Central Java. The system consisted of a 28 m communication tower connected to a server building via a 15 m outdoor UTP Ethernet cable utilizing Power-over-Ethernet technology. Following a thunderstorm and a power outage exceeding 24 hours, four network devices (one PoE injector, two MikroTik CRS326 switches, and one D-Link DGS-1100-24 switch) were damaged, while the Dell PowerEdge R360 server remained operational after a manual restart.

Failure analysis indicates that the damage resulted from surge propagation caused by ground potential rise (GPR) at the tower grounding system. The presence of separate and unbonded grounding systems, combined with the conductive copper PoE link, created a low-impedance path for transient currents.

The findings highlight the vulnerability of hybrid infrastructures that employ copper Ethernet links between structures with independent grounding systems, particularly in high-lightning-activity tropical regions. This study provides real-world evidence supporting the critical importance of coordinated grounding, surge protective devices (SPDs), and the adoption of optical fiber as the preferred communication medium for tower-to-building links.

For Indonesian telecommunication operators and PLN, this case underscores the need to revise installation guidelines for communication towers. Replacing copper links with fiber optics or implementing equipotential bonding and SPDs can significantly reduce lightning-related downtime and equipment loss. Policy recommendations include mandating optical fiber or shielded surge-protected links in all new hybrid tower installations.

Future work should involve field measurements of GPR and surge waveforms, as well as simulation validation using tools such as ATP-EMTP or PSCAD to quantify the effectiveness of protection strategies.

## 5. Acknowledgement

The authors would like to thank the site operator for providing access to the facility and sharing detailed information regarding the incident timeline and system configuration.

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**Conflict of Interest**

The authors declare that there is no conflict of interest regarding the publication of this article.

## 6. References

[1] A. I. Omar, M. Mohsen, M. A. Abd-Allah, Z. M. Salem Elbarbary, and A. Said, “Induced Overvoltage Caused by Indirect Lightning Strikes in Large Photovoltaic Power Plants and Effective Attenuation Techniques,” *IEEE Access*, vol. 10, pp. 112934–112947, 2022, doi: 10.1109/ACCESS.2022.3216866.

[2] N. Rameli, M. Z. A. Abd Kadi, M. Izadi, and N. Azis, “Effects of Lightning Electromagnetic Field due to Lightning Strikes on a Tall Structure,” *JEESR*, pp. 23–28, Oct. 2023, doi: 10.24191/jeesr.v23i1.003.

[3] D. Mestriner, R. A. Ribeiro De Moura, R. Procopio, and M. A. De Oliveira Schroeder, “Impact of Grounding Modeling on Lightning-Induced Voltages Evaluation in Distribution Lines,” *Applied Sciences*, vol. 11, no. 7, p. 2931, Mar. 2021, doi: 10.3390/app11072931.

[4] B. Denov, S. Hidayat, Suwarno, and R. Zoro, “A Method to Obtain Lightning Peak Current in Indonesia,” *Energies*, vol. 16, no. 17, p. 6342, Sep. 2023, doi: 10.3390/en16176342.

[5] N. Sagita and T. Takemi, “Influences of Indian Ocean Dipole and El Niño–Southern Oscillation on Thunderstorm Events in Indonesia,” *Intl Journal of Climatology*, vol. 45, no. 11, p. e8931, Sep. 2025, doi: 10.1002/joc.8931.

[6] Y. Elhakim, T. Ismail, and I. Fahim, “Optimum Selection of Communication Tower Structures Based on Wind Loads & lifecycle cost analysis,” *Cogent Engineering*, vol. 9, no. 1, p. 2132656, Dec. 2022, doi: 10.1080/23311916.2022.2132656.

[7] C. Yeung *et al.*, “Transient induced response on cables by lightning electromagnetic pulse with different experimental conditions,” *Electric Power Systems Research*, vol. 238, p. 111031, Jan. 2025, doi: 10.1016/j.epsr.2024.111031.

[8] *IEEE Guide for Surge Protectors and Surge Protective Circuits Used in Information and Communication Technology Circuits (ICT), Including Smart Grid--Part 1 Applications*. doi: 10.1109/IEEESTD.2020.9032423.

[9] P. H. Pretorius, “On Lightning Ground Potential Rise and Wire- Line Communications in Large Utility Scale PV Plant,” in *2022 36th International Conference on Lightning Protection (ICLP)*, Cape Town, South Africa: IEEE, Oct. 2022, pp. 705–713. doi: 10.1109/ICLP56858.2022.9942579.

[10] R. Alipio, M. Guimarães, L. Passos, D. Conceição, and M. T. C. de Barros, “Ground potential rise in wind farms due to direct lightning,” *Electric Power Systems Research*, vol. 194, p. 107110, 2021.

[11] C. Peng, J. Yang, and J. Zou, “Influence of equipotential bonding on the lightning transient characteristics of high-speed railway grounding system,” *IET Conf. Proc.*, vol. 2022, no. 5, pp. 323–327, Jul. 2022, doi: 10.1049/icp.2022.1208.

[12] I. M. Y. Negara, D. Fahmi, D. A. Asfani, I. S. Hernanda, R. B. Pratama, and A. B. Ksatria, “Investigation and Improvement of Standard External Lightning Protection System: Industrial Case Study,” *Energies*, vol. 14, no. 14, p. 4118, Jul. 2021, doi: 10.3390/en14144118.

[13] M. Zhou *et al.*, “Lightning inductive coupling characteristics of parallel cables: Computation and measurement validation,” *IET Science Measure & Tech*, vol. 17, no. 3, pp. 115–124, May 2023, doi: 10.1049/smt2.12135.

[14] C. Li, X. Wen, L. Guo, J. Chen, J. Chen, and H. Lu, “Hazard evaluation of ground potential difference within grounding grid on personal safety under impulse current,” *IET Science Measure & Tech*, vol. 15, no. 6, pp. 544–550, Aug. 2021, doi: 10.1049/smt2.12055.

[15] L. Zhang *et al.*, “Immunity study: Port impedance measurement of PMU and PCI testing under EMP,” *IEEE Transactions on Industry Applications*, vol. 59, no. 6, pp. 7250–7258, 2023, doi: 10.1109/TIA.2023.3296394.

Informatics, Electrical and Electronics Engineering (Infotron)
Volume 6, Number 1, (2026) pp. 67-78
ISSN 2798-0197

[16] International Electrotechnical Commission, "IEC 61000-4-5:2014, Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test," Geneva, Switzerland, IEC 61000-4-5:2014, 2014. [Online]. Available: iec.ch

[17] Texas Instruments, "Protecting Ethernet Ports from Surge Events," SLVAE50A, Apr. 2022.

[18] N. M. Seniari *et al.*, "Analisis Intensitas Medan Listrik pada Pemukiman akibat Sambaran Petir pada Menara Base Transceiver Station Analysis of Electric Field Intensity in Residential Areas Due to Lightning Strikes on Base Transceiver Station Towers," *jppipa, pendidikan ipa, fisika, biologi, kimia*, vol. 11, no. 4, pp. 964–972, Apr. 2025, doi: 10.29303/jppipa.v11i4.8550.

[19] N. W. Priambodo, B. B. S. D. A. Harsono, and A. Junaidi, "Performance evaluation of lightning protection methods for transmission line in Indonesia," presented at the Proceedings of the Symposium on Advance of Sustainable Engineering 2021 (SIMASE 2021): Post Covid-19 Pandemic: Challenges and Opportunities in Environment, Science, and Engineering Research, Bandung, Indonesia, 2023, p. 050031. doi: 10.1063/5.0139290.

[20] H. Chikeur, B. Nekhoul, B. Harrat, and B. Khelifi, "Lightning induced disturbances in the power network considering losses, frequency effect and non-linearities," *Electric Power Systems Research*, vol. 223, p. 109565, 2023, doi: https://doi.org/10.1016/j.epsr.2023.109565.

[21] Badan Standardisasi Nasional, *Sistem Proteksi Petir pada Bangunan Gedung*, SNI 03-7015-2004, Jakarta, Indonesia., 2004. [Online]. Available: https://henrikusgalih.wordpress.com/wp-content/uploads/2012/10/sni-03-7015-2004-proteksi-petir.pdf

[22] Badan Standardisasi Nasional, *Tata Cara Perencanaan Proteksi Bangunan dan Peralatan terhadap Sambaran Petir*, SNI 03-6652-2002, 2002.

[23] J. Randolph, "Introduction to lightning and AC power fault surge protection for telecom signaling cables," in *2012 IEEE Symposium on Product Compliance Engineering Proceedings*, IEEE, 2012, pp. 1–11.

[24] A. Chandimal and C. Gomes, "Lightning related effects on the neighborhood of telecommunication tower sites," in *2012 International Conference on Lightning Protection (ICLP)*, IEEE, 2012, pp. 1–6.

[25] A. Beutel and J. Van Coller, "Surge protection of low voltage power systems for cellular telecommunications sites," in *2003 IEEE Bologna Power Tech Conference Proceedings,* IEEE, 2003, pp. 7-pp.

[26] B. Denov and R. Zoro, "Review of NFPA 780 Standard Compliance for Improved Lightning Protection in Indonesia's Oil and Gas Industry," *Energies*, vol. 18, no. 15, p. 4002, Jul. 2025, doi: 10.3390/en18154002.

[27] I. G. A. M. Sunaya, I. G. N. Sangka, I. M. Purbhawa, I. G. K. S. Budarsa, and I. K. Parti, "Installation of Electrostatic Lightning Protection System at Mranggen Village Office, Srumbung District, Magelang, Central Java," in *Proceedings of the International Conference on Sustainable Green Tourism Applied Science - Engineering Applied Science 2025 (ICOSTAS-EAS 2025)*, vol. 280, in Advances in Engineering Research, vol. 280. , Dordrecht: Atlantis Press International BV, 2025, pp. 411–420. doi: 10.2991/978-94-6463-878-3_46.

[28] R. Masri, I. A. Djufri, and R. Rasyid, "Evaluation of the Lightning Protection System at the Khairun University Rectorate Building," *MATEC Web Conf.*, vol. 372, p. 04006, 2022, doi: 10.1051/matecconf/202237204006.

[29] A. Zeddam and P. Degauque, "Current and voltage induced on telecommunication cables by a lightning stroke," in *Lightning Electromagnetics*, Routledge, 2017, pp. 377–400.

[30] R. Narayan, "Method for the design of lightning protection, noise control and grounding system at a telecom facility intelec® 2014," in *2014 IEEE 36th International Telecommunications Energy Conference (INTELEC)*, Vancouver, BC, Canada: IEEE, Sep. 2014, pp. 1–10. doi: 10.1109/INTLEC.2014.6972156.

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