

OPTIMAL DESIGN OF A SILENCER FOR ENHANCING NOISE REDUCTION IN A 5G BASE STATION

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Abstract

A 5G base station, also referred to as a 5G cell site or 5G cell tower, is a crucial component of a 5G wireless network infrastructure. It is responsible for providing wireless connectivity and enabling high-speed data transmission for 5G-enabled devices, such as smartphones, tablets, and other Internet of Things (IoT) devices. The components of the 5G base station are significantly more powerful than those of previous stations, such as 2G, 3G, and 4G. As a result, the cooling systems require more power and cause noise pollution to the environment. This study focuses on developing a novel silencer to reduce acoustic noise from servers in a 5G base station. The proposed silencer is made from high sound-absorbing materials to reduce noise. In addition, the silencer is designed with optimal vertical and horizontal ribs to enhance noise reduction while retaining comfortable airflow. The design performance was verified through simulations and validated by experiments.

Keywords: 5G base station; Design; Noise; Optimization; Silencer

Introduction

Noise pollution, also known as sound pollution, is the propagation of noise or sound that has a range of impacts on the health of both human and animal life. Every day, a considerable number of people suffer from the harmful effects of noise pollution. The potential health repercussions of exposure to loud noises include heightened blood pressure, cardiovascular disorders, disturbances in sleep patterns, and increased stress levels. These health issues can impact people of all age groups, with children being particularly vulnerable (National Geographic Society, 2025; Institution of Occupational Safety and Health, 2024). One of the primary health concerns is the rise in noise-induced

hearing loss (NIHL), a significant global health problem (Nelson *et al.*, 2005; Hong *et al.*, 2013). It is estimated that around 1.3 billion people worldwide suffer from hearing loss due to noise exposure (Vos *et al.*, 2012; Basner & McGuire, 2018). Remarkably, workplace noise exposure is responsible for 16% of adult hearing loss cases in the world (Basner *et al.*, 2014).

In recent years, 5G technology has gained significant attention, primarily due to its promise of enhanced communication capacity and reduced latency. However, these advantages come with drawbacks. Firstly, the data increasingly transfers through the telecom hardware. As a result, the

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thermal load is greater, necessitating more robust cooling mechanisms and leading to an increase in noise. For 5G servers, fans play an essential role in maintaining system temperature and are mainly used for cooling systems. However, the cooling system with a fan usually causes a sound noise of 91 dB at full load mode from a 1-meter distance, generated from various sources. When raising the rotational speed of a cooling fan, the frequency and intensity of the noise also increase (Curtis *et al.*, 2013; Chen *et al.*, 2016; Shinjo *et al.*, 2017). Prolonged exposure to its noise can be incredibly annoying for users, potentially leading to discomfort for the installer, affecting their work performance (Staff, 2018; Industrial Noise & Vibration Centre, 2025).

Noise isolation using soundproof cabinets is expensive and impractical in data centers, which seek to reduce floor space and communication losses. Alternatively, a cooling system using a liquid can be applied; however, such a system is bulky and complicated. Thus, silencers are the best method for reducing sound noise in a 5G base transceiver station (BTS) due to their compact size and cost-effectiveness, playing an important role in industrial fields to mitigate noise emissions and safeguard the well-being of workers. When designing a silencer using fans, it is essential to ensure that the exhaust system is well-matched in size and form to satisfy the predefined space constraints. In addition to its sound-absorbing materials, the silencer is capable of withstanding high temperatures and corrosion. According to the literature, a few noise reduction technologies have been applied to telecommunications. For instance, McKay proposed the design of a segmented membrane sound absorber (SeMSA), which is effective in absorbing acoustic noise at low frequencies (McKay *et al.*, 2020; Davis *et al.*, 2021). SeMSA employs a visco-thermal loss mechanism of a micro-perforated plate and membrane resonators, resulting in the best-performing sound-absorbing solution in the 20-1200 Hz range. Likewise, Choy *et al.* developed reinforced composite plates to control low-frequency noise (Choy *et al.*, 2012). Their silencer plate performed well at flow speeds of less than 15 m/s. In a recent development, Huang presented a novel design of a drumlike silencer comprising a pair of highly stretched membranes, enveloped by two cavities (Huang, 1999; Choy and Huang, 2002). Remarkably, this silencer exhibits the best performance at flow speeds of up to 20 m/s, which is the maximum flow speed encountered in most ventilation systems. Furthermore, Lawrie contributed to this field by presenting a hybrid mode-matching method to analyze the drumlike silencer. His research evaluated the performance of

this silencer with different membrane positions (Lawrie and Guled, 2006). It is important to note that applying tension to the membrane in a real-world ventilation system poses practical challenges. Another research group studied acoustic silencing methods employing membranes or plates with a tapered-width design. The introduction of tapered-width plates contributes to impedance variation within the duct, impacting the effectiveness of the membrane-based or plate-based silencers (Ramamoorthy *et al.*, 2002; Cheng and Grosh, 2008). However, the above-mentioned silencer design cannot be applied to the 5G BTS server due to the different structure of the subject. The rack of the 5G BTS requires a compact size and has certain limitations in working space. Thus, research on acoustic silencers for 5G BTS servers is still ongoing.

A silencer for reducing the acoustic noise of a 5G BTS server is proposed in this paper, designed with a sound-absorbing structure and assembled at the air-exhausting gates of the server fans. The objective of the project is to ensure a safe and comfortable working environment for employees by lowering the noise level to below 55 dB. This research involves three stages. Firstly, the simulation model in Ansys software is validated through an experiment. Secondly, this research investigates various silencer designs to identify the best structure. In the final stage, the number of vertical and horizontal ribs is optimized based on the evaluation criteria for the reduction in acoustic noise.

Materials and Methods

Methodology

The structure of the silencer requires maximum noise absorption to reduce the sound of the fan to the hearing threshold of humans. The structure of the silencer also needs to fit the 5G server; the height of the proposed silencer is less than 1.75 inches to conventionally integrate with the server's rack. The final requirement is to ensure easy thermal transfer through the air convection process.

The proposed design of the silencer is shown in Figure 1. It is made by damping materials and forming a rectangular duct. Since the fans are positioned at the rear of the server, the silencer has a compact, L-shape structure that fits its fabricated rack. The design of the silencer wall follows a theoretical approach aimed at integrating it with the propagating plane wave, leading to optimal attenuation of the combined mode pair. The wall impedance is characterized by two modes in the complex wave-number plane. It is important to

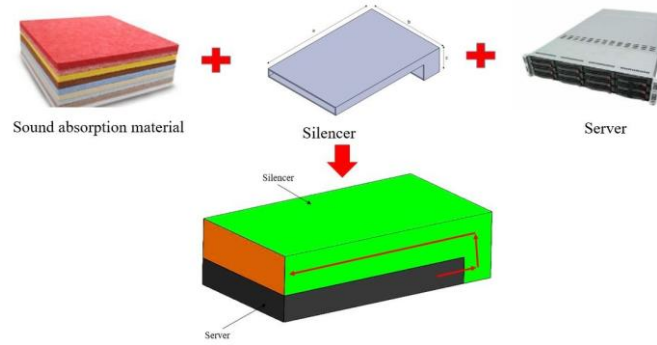


Figure 1. Assembly of the silencer and server

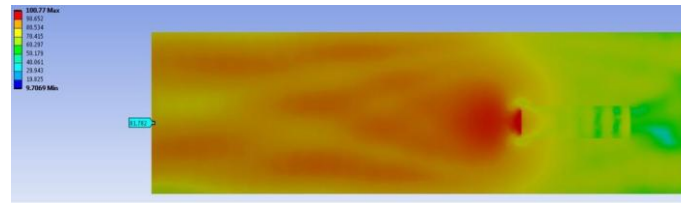


Figure 2. 5G server without a silencer in simulation

highlight that an attenuation peak occurs for the propagation of these modes within the duct. The wall impedance can be identified as Equation 1.

$$Z_{wall} = (0.9288 - 0.7442i) \frac{kh_1}{\pi} \quad (1)$$

Where h_1 is a duct height, k is the wave number, and i is an imaginary unit. The silencer design incorporates a rectangular chamber and plate, creating Cremer impedance across multiple frequencies. The combined impedance of the wall and chamber can be represented as Equation 2.

$$Z_{tot} = Z_{wall} + Z_{chamber} \quad (2)$$

The impedance of the wall, Z_{wall} , is contingent on the material used for the chamber, which could be rubber or a composite. The impedance of the chamber is determined by Equation 3.

$$Z_{chamber} = Z_0 \frac{1 + e^{ik \cdot 2h_2}}{e^{ik \cdot 2h_2} - 1} \quad (3)$$

Where h_2 represents the depth of the expansion chamber.

Simulation model

The application of numerical simulation methods has become increasingly important in the design of silencers. The finite element method (FEM) provides the effective integration of model

flexibility, computational efficiency, and accuracy of results. The sound values are obtained through simulation in Ansys software. A 3D model of the assembly between the silencer and the server is built in SolidWorks software, as shown in Figure 2.

The pressure source is defined by Equation 4.

$$\frac{w}{s} = \frac{\bar{p}}{\rho_0 c} \quad (4)$$

Where c denotes the sound velocity, ρ_0 represents the air density, and S is the area of the surface. Equation 4 is reformulated as indicated in Equation 5.

$$P_{intake} = \sqrt{2} \times \sqrt{\rho_0 c \frac{w_{ref} \times 10 \left(\frac{LW}{10} \right)}{h_{intake} \times b_{intake}}} \quad (5)$$

Where W_{ref} denotes the reference sound power, h_{intake} and b_{intake} represent the height and width of the intake, respectively. The sound values recorded by the measurement devices do not incorporate phase parameters. However, the phase can be estimated by considering the distance from the fans to the exhaust. In this model, the distance L from the fans to the exhaust is 120 mm, and the air path (L_{air}) along the duct is 300 mm. Due to the dipole nature of the fan noise source, the phase undergoes a shift of π radians. The resulting phase shift is described by Equation 6.

$$\varphi = (0.3 - 0.12) \frac{2\pi f}{c} + \pi \quad (6)$$

Where f represents the frequency. The sound power for both exhausts is measured across a frequency range. Consequently, the pressure source for each exhaust is calculated by Equation 7.

$$\hat{p}_{exhaust} = \sqrt{\rho_o c \frac{W_{ref} * 10(\frac{LW}{10})}{h_{exhaust} * b_{exhaust}}} e^{i(0.27 - 0.09) \frac{2\pi f}{c} + \pi} \quad (7)$$

In the case of utilizing multiple fans in conjunction with the interior BBU, their joint performance will be affected. To effectively implement a solution utilizing Cremer damping for sound reduction, the sound must traverse a cross-sectional area featuring walls that conform to the Cremer optimum. To achieve this objective, various duct solutions must be implemented.

To assess the approach employing Cremer material, the acoustic module in Ansys software is used to predict the silencer performance, saving time and the manufacturing cost of the prototype. The purpose of the simulation is to provide an estimation of the sound power spectra for the entirety of the shroud. An additional objective is to choose a suitable damper material for achieving the lowest possible total sound power level. The specified frequencies are derived from the BBU and RRU 5G operation bands. The simulation frequency is configured at 5000 Hz. The acoustic sound simulation is executed through a series of steps. Firstly, a simulation model is generated for validation purposes. Secondly, various silencer designs are investigated to identify the best structure. The final stage involves optimizing the number of vertical and horizontal ribs based on the evaluation criteria for the reduction in acoustic noise.

Validation for the simulation process

In fields such as engineering and product development, simulations are used to test prototypes and explore various design options before committing to physical production. This can save time and resources in the development process. In this process, validating a simulation model is a crucial step in ensuring that the simulation accurately represents the real-world system. Validation is the process of assessing the degree to which a simulation model is an accurate and reliable representation of the actual system. Thus, the simulation model without silencers needs to be validated through an experiment prior to its implementation in future research. The design of the 5G server is sketched in the Harmonic Acoustics Module of Ansys software, as shown in Figure 2; its

dimensions are $670 \times 435 \times 132$ in length, width, and height, respectively. The analysis took approximately six hours, with the configuration of one computer being 64 GB RAM, Ryzen 9 3900X (3.8 GHz, 70 MB cache, 12C/24T) chip. The acoustic source was predefined at six fan positions ($0.05\text{--}0.06 \text{ kg/m}^2\cdot\text{s}$). According to the simulation results, the acoustic noise value varied in the range from 9.71 dB to 100.77 dB. At a 1-meter distance from the 5G server's fan, the sound level was 81.782 dB. The experiment results are described in Figure 3. At the same distance point, the measured value by the sound instrument PCE-999 was 84.9 dB. The error of the simulation process was 3.81%, which is less than 5%, confirming its acceptability for use in addressing engineering problems. Consequently, the simulation model was confirmed to be similar to the real experiment and could therefore be used for the next steps of this research.

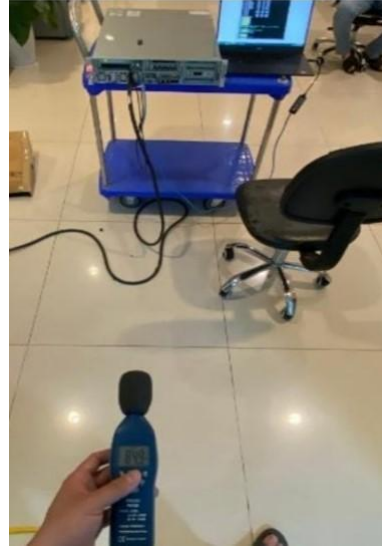


Figure 3. 5G server without a silencer in the experiment

Results and Discussion

Investigating various silencer structures

This section investigates the effect of various configurations of the proposed silencer on its noise reduction performance to identify the best structure for a 5G server. The criteria of the selection are maximum sound reduction at a 1-meter distance from the server's fan. Four types of silencers are designed in this research to evaluate their effectiveness in reducing acoustic noise, as described in Table 1. Generally, all silencers are designed in an L shape, with the cover made from aluminum and the inner surface covered by sound-absorbing materials, as described in Figure 4. However, each

type of silencer box is different in length and material. Specifically, models 1 and 3 are short silencer boxes, half the length of the server box, while models 2 and 4 are equal in length to the server box. Models 1 and 2 are made from PET foam, while models 3 and 4 are made from waveform PE foam.

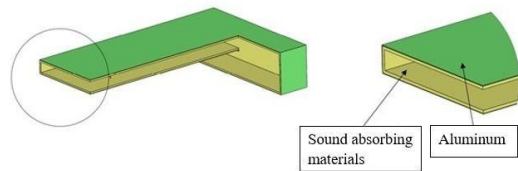


Figure 4. Materials used for the silencer

Table 1. Structural parameters of the silencer

No.	Situation	Dimensions (a×b×c)
1	Short silencer box with PET foam	335×435×132
2	Long silencer box with PET foam	670×435×132
3	Short silencer box with waveform PE foam	335×435×132
4	Long silencer box with waveform PE foam	670×435×132

The simulation results are shown in Figure 5 and Table 2. As can be observed, the maximum noise reduction reaches 9.48 dB, corresponding to the long silencer box with waveform PE foam. Table

2 encapsulates the outcomes of a series of simulations, shedding light on the effectiveness of various silencer box configurations in mitigating the noise generated by the 5G telecom base station. The simulations reveal the sound intensity levels (in dB) for each scenario, alongside the corresponding reductions (in dBA).

In the absence of a silencer box, the base station emits a substantial sound intensity of 81.78 dB, setting the baseline for comparison. However, the introduction of different silencer box configurations leads to significant reductions in noise levels. Notably, the short silencer box equipped with PET foam achieves a substantial noise reduction of 5.560 dBA, bringing the sound intensity down to 76.22 dB. A similar trend of effectiveness is observed with the long silencer box featuring PET foam, which attains a reduction of 7.08 dBA, resulting in a sound intensity of 74.70 dB.

Moreover, the utilization of a short silencer box with waveform PE foam re-sults in a remarkable reduction of 7.87 dBA, lowering the sound intensity to 73.91 dB. Impressively, the long silencer box with waveform PE foam emerges as the most effective configuration, demonstrating a substantial noise reduction of 9.48 dBA, with the sound intensity decreasing to 72.30 dB. Therefore, the long silencer box with waveform PE foam is selected for the next stage of this study to optimize the number of ribs in the chosen silencer.

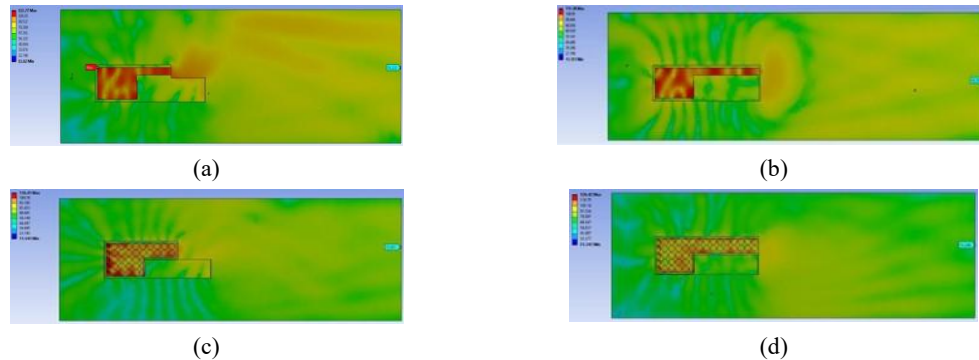


Figure 5. Four types of proposed silencers: a) Short silencer box with PET foam; b) Long silencer box with PET foam; c) Short silencer box with waveform PE foam; d) Long silencer box with waveform PE foam

Table 2. Simulation results using four types of proposed silencers

Simulation	Sound level at a distance of 1 m			Noise reduction (dBA)
	Maximum	Maximum	Maximum	
Without silencer	91.84	81.78	57.60	
Short silencer box with PET foam	79.48	76.22	74.06	5.56
Long silencer box with PET foam	77.30	74.70	70.92	7.08
Short silencer box with waveform PE foam	75.77	73.91	69.24	7.87
Long silencer box with waveform PE foam	74.04	72.30	68.01	9.48

Optimization of vertical and horizontal ribs

Number of vertical ribs

In this study, the number of vertical ribs was optimized, ranging from 3-8. The long silencer box with waveform PE foam was used for the simulation, with its structure divided into two parts (1) and (2) as presented in Figure 6. The two parts are rectangular in shape, with the height of part (1) being greater than its width, making it suitable for a vertical rib which is a thin plate made from stainless steel 304. Its parameters are expressed in Figure 7.

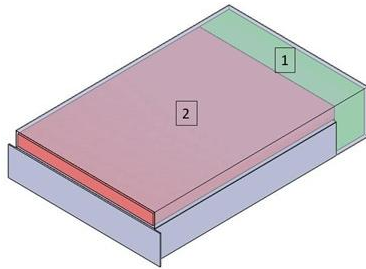


Figure 6. Silencer structure

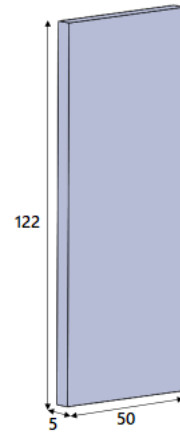


Figure 7. Geometric parameters of the vertical rib

In this simulation, six models of silencers with various vertical ribs were investigated as expressed in Figure 8. As can be observed from Figures 8a to 8f, the number of vertical ribs ranges from three to eight, with the ribs being equally positioned along the width of the silencer box. The simulation results are presented in Figure 9 and Table 3.

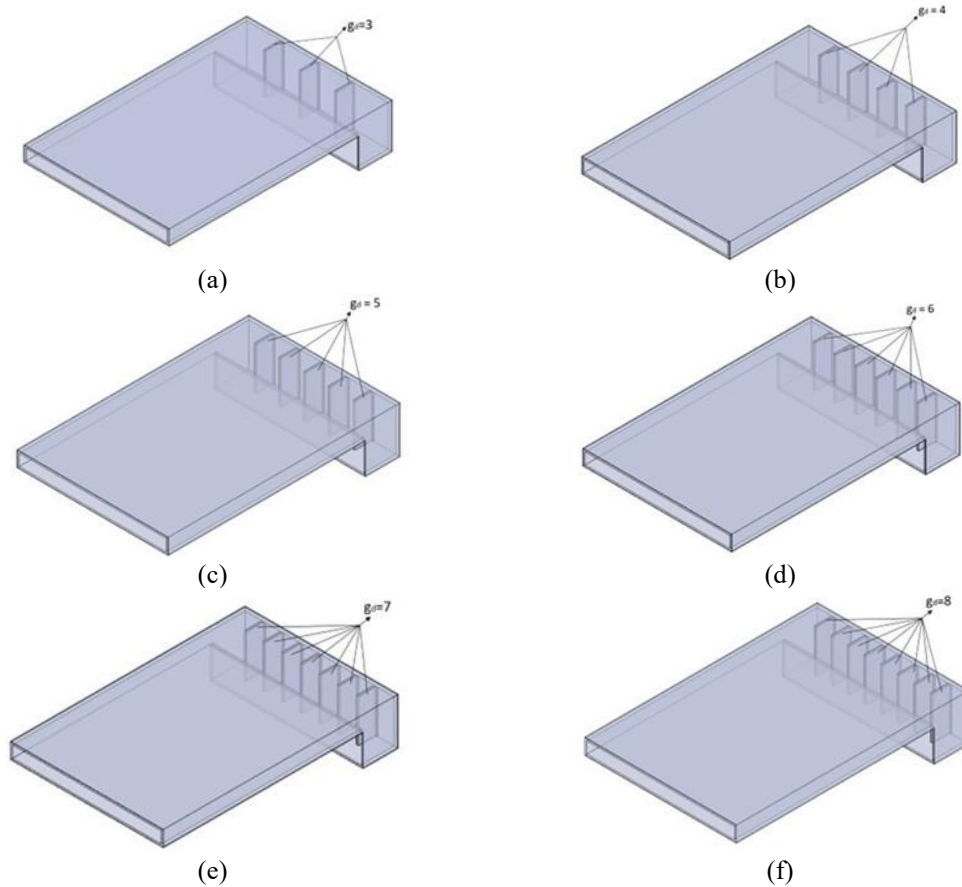


Figure 8. Silencer structure with various numbers of vertical ribs: a) 3 vertical ribs; b) 4 vertical ribs; c) 5 vertical ribs; d) 6 vertical ribs; e) 7 vertical ribs; f) 8 vertical ribs

Table 3. Simulation results for vertical ribs

Simulation	Sound level at a distance of 1 m			Noise reduction (dBA)
	Maximum	Maximum	Maximum	
Long silencer box without vertical ribs	74.04	71.30	68.01	
Silencer with 3 vertical ribs	74.77	61.04	36.42	10.26
Silencer with 4 vertical ribs	75.40	61.09	40.10	10.21
Silencer with 5 vertical ribs	75.86	61.75	43.35	9.55
Silencer with 6 vertical ribs	76.08	61.59	40.46	9.71
Silencer with 7 vertical ribs	75.15	61.25	41.28	10.05
Silencer with 8 vertical ribs	75.68	61.20	39.05	10.1

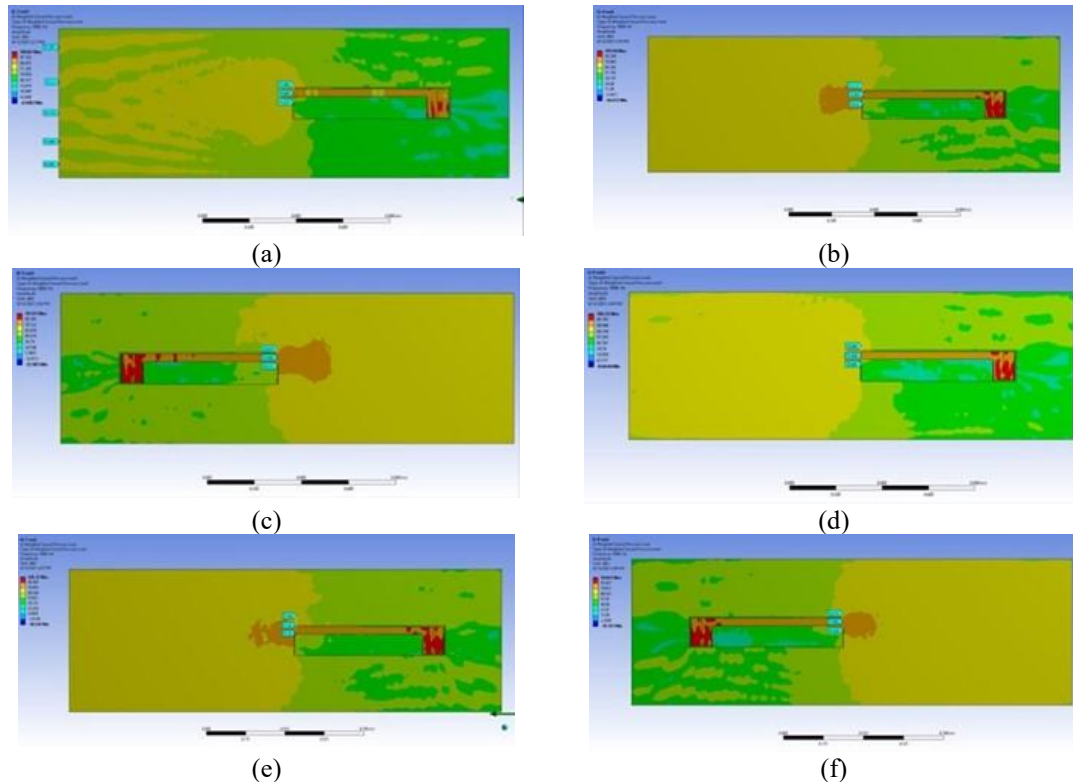


Figure 9. Sound noise diagram of a silencer with various numbers of vertical ribs: a) 3-vertical rib silencer; b) 4-vertical rib silencer; c) 5-vertical rib silencer; d) 6-vertical rib silencer; e) 7-vertical rib silencer; f) 8-vertical rib silencer

As can be seen in Figure 9, the cyan color expresses the minimum sound pressure level, while red presents the maximum. In general, the sound environment around the server is separated into two areas: in front of the silencer mouth in yellow and the rear in green. The maximum sound is concentrated at the right output of the silencer, in the position of the cooling fan. As can be observed from the graphs, the sound noise is guided from the fan to the left side of the server by the silencer, proving the effectiveness of the silencer in noise reduction.

Table 3 provides the sound pressure data at a 1-meter distance point away from the server. In the absence of a vertical rib, the server expels a sound pressure level of 71.30 dB, setting the baseline for comparison. Reputably, the integration of a vertical

rib into the silencer box leads to remarkable reductions in noise levels. Specifically, the silencer box equipped with three vertical ribs obtains a significant noise reduction of 10.26 dBA, bringing the sound intensity down to 61.04 dBA. A similar trend of effectiveness can be observed with the long silencer box consisting of four to eight vertical ribs, revealing a noise reduction ranging from 9-10 dBA. The utilization of the long silencer box with five vertical ribs results in a minimum reduction of 9.55 dBA, lowering the sound intensity to 61.75 dBA. In conclusion, the long silencer with three vertical ribs provides the most effective combination. Thus, this configuration was selected for the next stage of this study, namely, to identify the optimum number of horizontal ribs for the silencer.

Number of horizontal ribs

This study aims to optimize the number of horizontal ribs in the silencer. The horizontal ribs are equally positioned in part (2), as shown in Figure 6. Moreover, if there are fewer than three horizontal ribs, the noise absorption will not be affected, while more than six ribs make it difficult for air to flow from the cooling fan to the outside. Thus, the study investigates the use of three to six horizontal ribs. The parameters of the horizontal rib are expressed in Figure 10. The design of the silencer with various horizontal ribs is expressed in Figure 11, consisting of a thin plate made from

stain-less steel 304. From Figure 11a to 11d, the number of horizontal ribs ranges from three to six, with the ribs equally positioned along the length of the silencer box. The simulation results are shown in Figure 12 and Table 4.

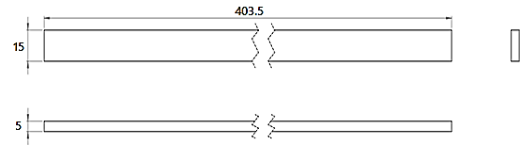


Figure 10. Geometric parameters of the horizontal rib

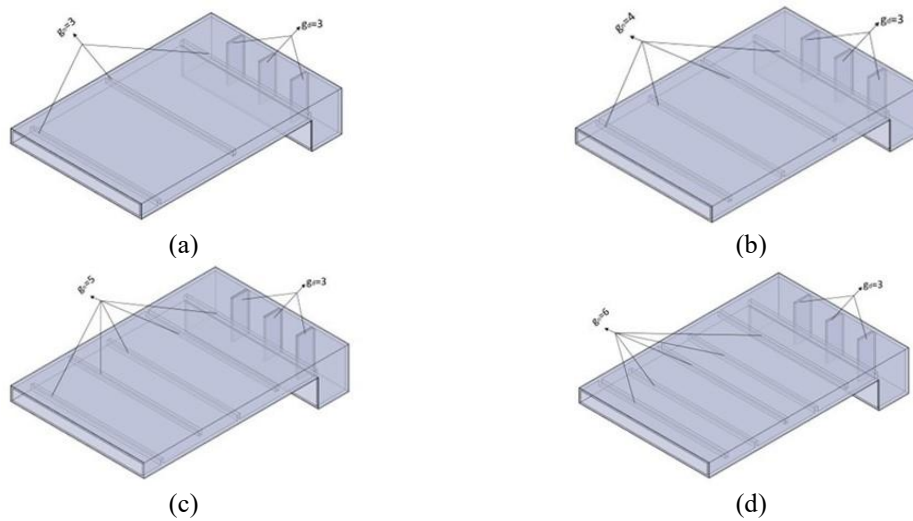


Figure 11. Silencer structure: a) 3-vertical and 3-horizontal ribs; b) 3-vertical and 4-horizontal ribs; c) 3-vertical and 5-horizontal ribs; d) 3-vertical and 6-horizontal ribs

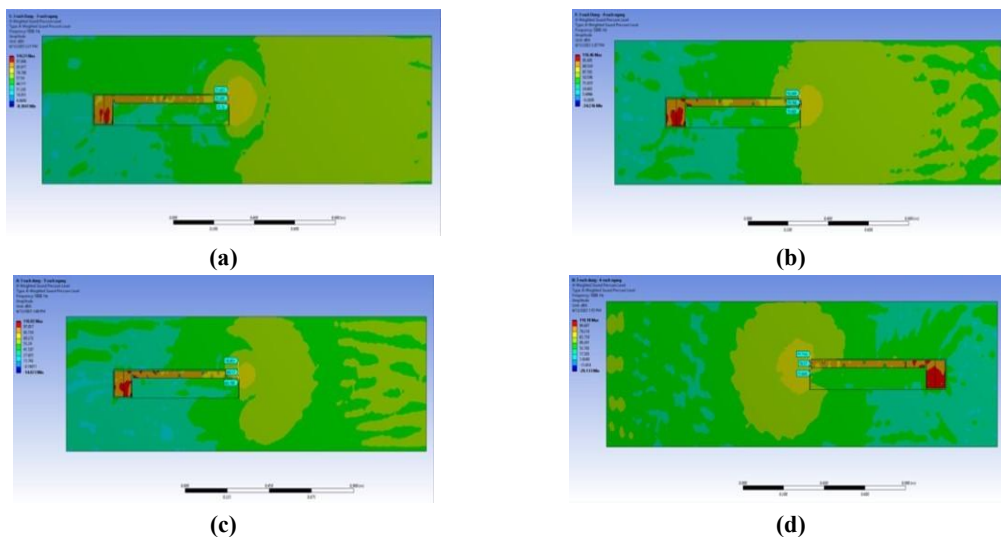


Figure 12. Sound noise diagram of a silencer with various horizontal ribs: a) 3-vertical and 3-horizontal rib silencer; b) 3-vertical and 4-horizontal rib silencer; c) 3-vertical and 5-horizontal rib silencer; d) 3-vertical and 6-horizontal rib silencer

Table 4. Simulation results with various numbers of horizontal ribs

Simulation	Sound level at a distance of 1 m			Noise reduction (dBA)
	Maximum	Maximum	Maximum	
3 vertical and 0 horizontal ribs	74.77	61.04	36.42	
3 vertical and 3 horizontal ribs	65.42	53.09	21.80	7.95
3 vertical and 4 horizontal ribs	55.09	41.33	8.15	19.71
3 vertical and 5 horizontal ribs	60.06	47.68	10.35	13.36
3 vertical and 6 horizontal ribs	50.34	38.46	7.49	22.58

In Figure 12, cyan indicates the minimum sound pressure level and red the maximum. In general, the sound environment around the server is separated into two areas: in front of the silencer mouth in yellow and the rear in green. The maximum sound is concentrated at the right output of the silencer, which is the position of the cooling fan.

The graphs show that noise is guided from the fan to the left side of the server by the silencer, proving its noise reduction effectiveness. When the number of horizontal ribs increases from three to six, the green area also expands, demonstrating that noise reduction effectiveness rises accordingly. However, too many horizontal ribs negatively impact the airflow of the cooling fan, and therefore six is considered to be the optimum.

Table 4 presents the sound pressure data at a 1-meter distance point away from the server. In the absence of a horizontal rib, the server expels a sound pressure level of 61.04 dB, setting the baseline for comparison. Reputably, the integration of a horizontal rib into the silencer box leads to remarkable reductions in noise levels. Specifically, the silencer box equipped with three horizontal ribs results in a significant noise reduction of 7.95 dBA, bringing the sound intensity down to 53.09 dBA. A similar trend of effectiveness can be observed with the silencer box containing four to six horizontal ribs. The utilization of the long silencer box with six horizontal ribs provides a maximum reduction of 22.58 dBA, lowering the sound intensity to 38.46 dBA, which, at less than 55 dBA, is the maximum sound noise criteria for the devices when working with humans (Ministry of natural resources and environment, 2010). Therefore, the long silencer with three vertical and six horizontal ribs was found to be the most effective configuration.

Effect of ribs on cooling system airflow

The next stage is to consider the effect of vertical and horizontal ribs on the airflow in the silencer. The air source is set to the input of part (1), and the output is appointed to part (2). The direction of the vertical ribs has less effect on the movement of the air, while the horizontal ribs tend to confront the airflow. As a result, the simulation is set up as follows: part (1) has three vertical ribs, while the

number of horizontal ribs in part (2) ranges from three to six. The simulation is shown in Figure 13 and Table 5. The graph of airflow is presented in Figure 14. As can be observed, red represents the maximum velocity of the air while blue expresses the minimum. In all simulations, the air in part (1) of the silencer is always blue, meaning that the vertical ribs have no effect on the airflow. If there are no horizontal ribs, the airflow rate reaches the maximum at 0.07 (kg/s) since it will not encounter the horizontal ribs on the moving road. Meanwhile, the integration of horizontal ribs significantly decreases the airflow rate because the air will be obstructed. The airflow graph shows a wave-shaped curve. When the number of horizontal ribs increases, so do the airwave cycles. The phase transfer points at the horizontal ribs are presented in red. Table 5 expresses the airflow rate data in the silencer, with three to six horizontal ribs. The airflow rate is almost constant and equals around 0.04 (kg/s), which ensures that the cooling process of the 5G server works normally when adding the vertical and horizontal ribs.

Table 5. Airflow rate with various numbers of horizontal ribs

Situation	Airflow rate (kg/s)
3 <i>gd</i> - 0 <i>gn</i>	0.0713
3 <i>gd</i> - 3 <i>gn</i>	0.0415
3 <i>gd</i> - 4 <i>gn</i>	0.0404
3 <i>gd</i> - 5 <i>gn</i>	0.0398
3 <i>gd</i> - 6 <i>gn</i>	0.0384

Figure 15 shows the assembly of the optimized silencer into the server. The silencer was tested using three modes: the optimal fan with no load, the optimal fan with load, and full speed with the load in the laboratory. The PCE-999 sound level meter was set at a 1-meter distance from the 5G server's fan.

Table 6 presents a comparison of two experimental results: without and with the use of the optimized silencer to verify the effectiveness of the proposed approach. As can be observed, in general, the sound noise reduces in the range of 13.2-22.2 dBA while the temperature of the air at the output gate ranges from 0-1 °C. With the

optimized silencer, the maximum and minimum temperatures reach 48 °C and 33 °C, respectively. According to Webber (2014), an IC operating continuously at 105 °C will have a lifetime of approximately 85,000 hours, while the lifetime of

the IC is re-duced by half when the operating temperature increases by 10 °C. This indicates that the utilization of the proposed silencer results in a negligible increase in server tem-perature and does not affect the lifespan of the IC.

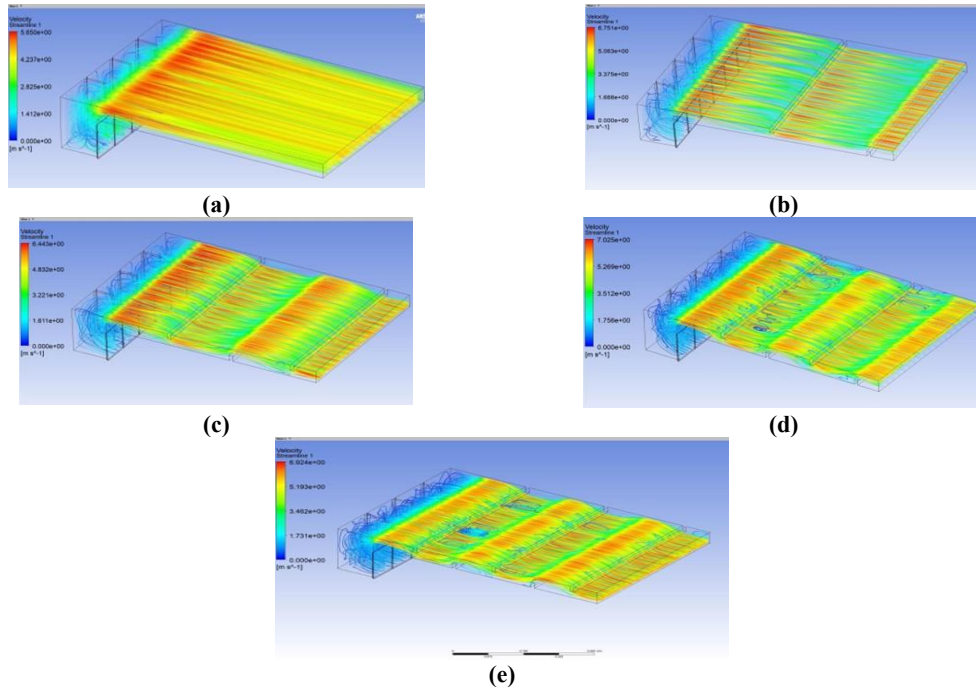


Figure 13. Airflow diagram of a silencer with various horizontal ribs: a) 3-vertical and 0-horizontal rib silencer; b) 3-vertical and 3-horizontal rib silencer; c) 3-vertical and 4-horizontal rib silencer; d) 3-vertical and 5-horizontal rib silencer; e) 3-vertical and 6-horizontal rib silencer

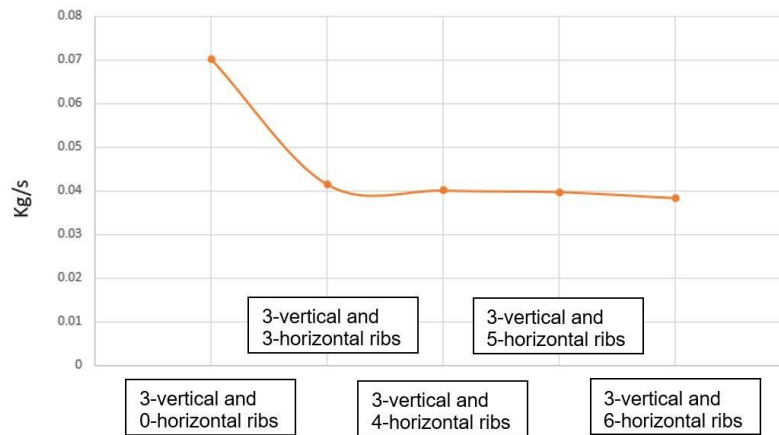


Figure 14. Graph of airflow rate with various horizontal ribs.

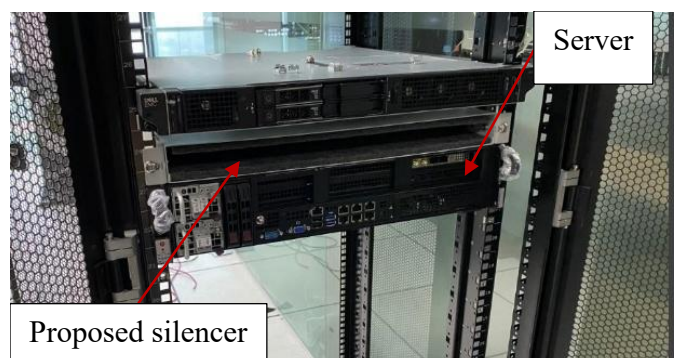


Figure 15. Experiment using the proposed server

Table 6. Comparison of experimental results

Situation	Without silencer		With silencer	
	Sound noise (dBA)	Temperature (°C)	Sound noise (dBA)	Temperature (°C)
Optimal fan with no load	64.5	32	42.3	33
Optimal fan with load	68.0	48	54.8	48
Full speed with load	84.9	40	66.7	41

Conclusion

This study uses the FEM in Ansys software to successfully identify the optimum number of vertical and horizontal ribs. The simulation model was validated to closely match the experimental result for the 5G server. The optimal silencer can noticeably reduce the emitted sound from the cooling fan of the server. This research proves that the L-shape silencer with the configuration of three vertical and six horizontal ribs is the most effective combination for sound noise reduction in a 5G server. When using the optimal silencer, the mean sound pressure satisfies the sound noise criteria of the devices (under 55 dBA). The results of this study also prove that the integration of the optimal silencer does not affect the lifespan of the 5G server.

Acknowledgments

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