Journal of the Society of Automotive Engineers Malaysia
Volume 7, Issue 2, pp 138-142, May 2023
e-ISSN 2550-2239

Vehicle Alarm Characteristics and Vehicle-Driver Distance for Child Presence Detection (CPD) System

M. H. A., Ali[1], R., Murali[1], **A. B. Shahriman***[1], M. Mohamed[1], Z. M. Razlan[1], M. F. H. Rani[2], A. Abashah[1], A. A. Othman[3] and G. Ramasamy[1]

[1] Universiti Malaysia Perlis (UniMAP), 02600 Arau, Perlis, Malaysia
[2] Universiti Teknologi Malaysia (UTM), 81310 Johor Bahru, Johor, Malaysia
[3] Universiti Utara Malaysia (UUM), 06010 Sintok, Kedah, Malaysia

*Corresponding author: shahriman@unimap.edu.my

Car-TOON ***Open Access***

The Child Presence Detection (CPD) system is crucial in alerting drivers of a locked child in a car. This study aims to elucidate the car alarm characteristics and the car-driver distance in effectively alerting the drivers. It was found that low-frequency multi-tone alarms can effectively alert drivers as they could travel longer than high-frequency single-tone alarms. Findings from this study could help in further studies for an effectual CPD system.

Graphic: By RONA or Ms. Roziani Mohd Nasir, a lecturer at Universiti Teknologi MARA (UiTM) Machang Campus, specializing in Visual Communication.

KEYWORDS: Child Presence Detection (CPD), child safety, ASEAN NCAP

Article History:

Received 30 Mar 2023 | Accepted 15 Apr 2023 | Available online 1 May 2023

A vehicle alarm is an electronic device that is installed to identify an intrusion. These alarms work by emitting high-volume sounds when the conditions necessary for triggering them are met (Kouno & Ishimaru, 2017). In most cases, a car alarm is used to alert that someone is left in a locked car, and most of the time, this happens to children. This scenario is well-known in Malaysia, where parents' busy work schedules and demanding lifestyles often lead to hasty decision-making (Carmel et al., 2017). This alarm could be triggered by using a Child Presence Detection (CPD) system. This system is an exact and reliable mechanism to detect even the vital signs of sleeping newborns (Rosli et al., 2019). When an unattended child is detected, the vehicle's alarm and communications systems can alert parents or passersby that a child is still in the car. However, even with the current CPD system, there is no significant impact because the alarm can’t be heard after a particular time and there are no standardized alarm tone characteristics for the CPD system.

The research conducted by Vaillancourt et al. (2013) shows that in the S/N≥0 dB procedure, comparatively higher levels are required for the tonal alarm than both multi-tone and broadband alarms. A greater mean S/ N and standard deviations were also documented for the tonal alarm, implying higher sound level variations for the design. A robust tonal alarm had well-pronounced acoustic interferences, which tend to be layered out smoothly. It is concluded that a broad-frequency alarm has advantages over conventional tonal alarms (Vaillancourt et al., 2013). According to Laroche et al. (2018), a lower reaction threshold was detected in the broadband alarm rather than in the tonal alarm. A lower threshold indicates it is superior. At the same time, it was the opposite in the detection threshold data, where the tonal alarm had a lower detection threshold. Reverse alarms were concluded well audible in levels below background noises, where detection thresholds were overly sensitive.

Therefore, the tonal alarm was easier to notice in varying hearing protection conditions with a lower threshold (on average) (Laroche et al., 2018). Popoff-Asotoff et al. (2012) say that, through initial comparison, five of the ten tonal alarms assessed did not meet ISO 9533 criteria for being at least 3 dB(A) higher than vehicle noise. However, seven showed better drop-offs when placed behind vehicles when evaluating the ten broadband alarms. The discernible second set of tests suggests that the auditory pattern emitted by a vehicle's alarm system is notably irregular in the case of 'tonal' alarms, while it exhibits a more consistent and uniform nature in the case of 'broadband' alarms; it also showed the failure rate to comply the ISO 9533 criteria was 36 % with a high possibility to increase up to 45%. Broadband alarms were significantly more effective at reducing ambient noise levels in the third set of experiments (as opposed to tonal alarms). Even at 97 dB, broadband alarms were barely noticeable at 200 m and utterly silent at 400 m, while tonal alarms were still audible. At 87 dB, tonal alarms sometimes disappeared at 400 m, equivalent to a 102 dB broadband alarm. In summary, the low-frequency tonal alarm can be heard from far away (400m); however, it is not easy to notice because the alarm sound is irregular (Popoff-Asotoff et al., 2012). Based on the research conducted by Salleh et al. (2013), broadband and tonal signals have been identified as the most suitable options for serving as backup sounds in Electric Vehicles (EVs) to alert pedestrians effectively. In the annoyance assessment, most participants categorized these two signals within the 'moderate' range (Salleh et al., 2013). From the past studies, it can be concluded that most studies coincide that single-tone alarms are the hardest to notice and have the most impact on hearing. The absence of comparative research between high-frequency single-tone signal alarms and multi-tone or broadband alarms is a significant concern.

This study focuses on correlating the car alarm characteristics and the car-driver distance to effectively alert the drivers of a locked child. The alarm audio of Honda City 2014 and Proton Suprima 2013 was used for this study. The car alarm experiment was conducted at Universiti Malaysia Perlis (UniMAP), where the obtained data was analyzed using ANOVA variance of analysis to ensure the accuracy of the results. This research has collaborated with the Malaysian Institute of Road Safety Research (MIROS) and the New Car Assessment Program for Southeast Asian Countries (ASEAN NCAP). From the result, it was found that a low-frequency multi-tone alarm can effectively alert drivers compared to a high-frequency single-tone alarm. It was also found through ANOVA variance of analysis that the optimal car alarm characteristics in alerting drivers are notably different from each other (p-value < 0.05). It is expected that the findings from this study can be used to establish a framework for regulatory bodies to set standards on optimal car alarm characteristics for car manufacturers in effectively alerting drivers.

Car Alarm Sound Measurement

Honda City 2014 and Proton Suprima 2013 were used to measure the car alarm sound. Both alarm sounds were obtained to be replicated and assessed in a closed area. The experiment followed all the protocols and ISO 3744:2010 standards (Barbosa & Bertoli, 2017), in which the wind speeds were slower than 5 m/s (Abdullah et al., 2021). The car alarm sound was measured using the Tenma 72-942 (IEC61672-Type 2) sound level meter (Katalin, 2018; Segaran et al., 2019; Segaran et al., 2020). It used the A-weighted SPL and set the sound level meter in high mode to measure it more accurately (Segaran et al., 2019). The alarm sounds were recorded using a BM 800 professional microphone to get the detailed audio, as shown in Figure 1. The tripod is placed 1.5m above the ground before the sound pressure level at 0m for both cars is measured (Segaran et al., 2020; Abdullah et al., 2021). After obtaining the data, Proton Suprima and Honda City alarms were standardized at 110 dB by amplifying their original audio using the Audacity software. They were calibrated to be at 110 dBA at 0m distance. Then, the sound pressure level is measured from 0m to 20m distance, and by following the standard, there is no obstacle in a 3m radius, and the same standard is used for the alarm replication.

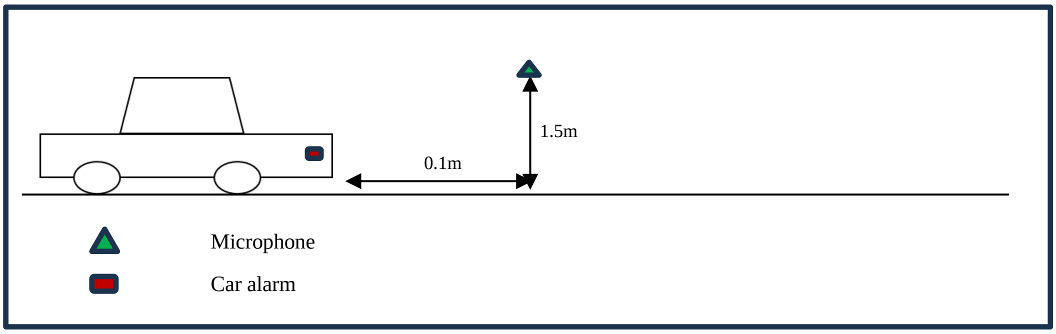

FIGURE 1: Illustration of alarm sound measurement setup

Result and Discussion

The measurement data collection for the Proton Suprima and Honda City alarms was repeated three times to conduct an uncertainty analysis. The scope of uncertainty analysis for this study is measurement and system uncertainty. The system uncertainty was obtained from the specification of the sound level meter (TENMA 79-942). The measurement uncertainty was obtained via Equation X (State-related equations below). The maximum uncertainty for the measured data was observed at 10m, which is 80.33 dBA ± 1.57 dBA or 1.95 %.

From Figure 2, the Proton Suprima alarm has a higher sound pressure level reading from 0m to 9m. The Proton Suprima alarm is single-tone, while the Honda City alarm is multi-tone; single-tone sounds travel further than multi-tone sounds due to their ability to focus their energy on a single direction. This is because single-tone tone sounds have a longer wavelength than multi-tone sounds, which allows them to travel more easily through obstacles. However, at 9m, the Suprima alarm drops lower than the City alarm, and the City alarm starts to lead in the SPL reading at the distance of 9m and onwards. The data proves that low-frequency alarms are more effective because the sound can be heard at a longer car-driver distance than high-frequency alarms (Rabaglia et al., 2016). The effect of alarm sound type on the sound pressure level after a certain distance must be studied more. The depicted data analyzes whether the sound exhibits a single or multi-tone characteristic at a specified distance. However, it is essential to note that the sound pressure level's primary determinant is the sound's frequency rather than its type.

Table 1 shows the result of the ANOVA variance of analysis; it can be observed that the P-value obtained is lower than 0.05, affirming the reliability of the measured data.

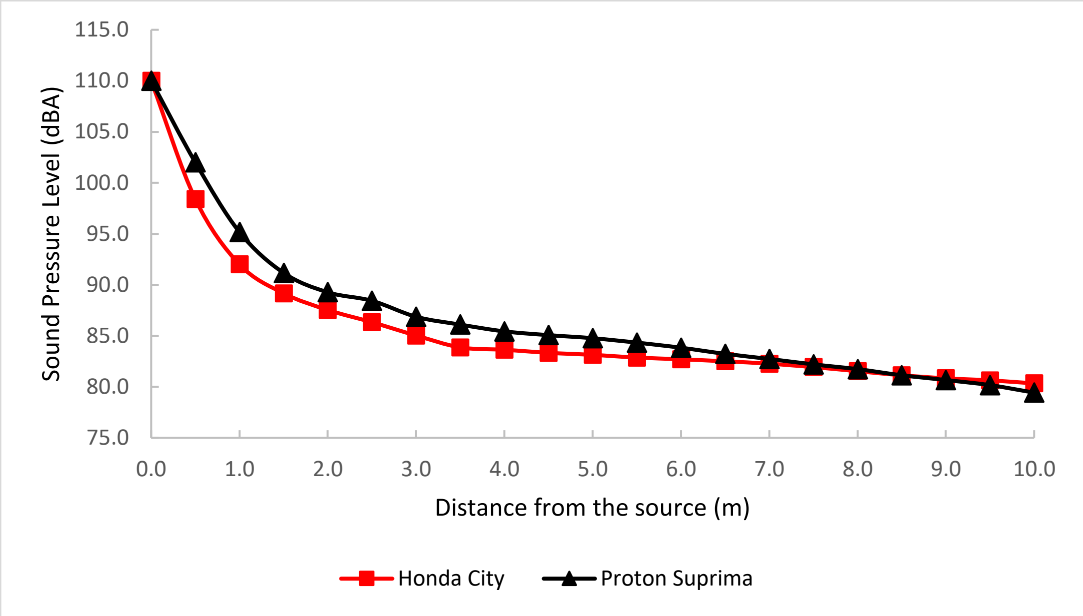

FIGURE 2: Standardized Sound Pressure level (dBA) at source (110 dBA) vs. distance (m)

TABLE 1: Analysis of Variance

Source	DF	Adj. SS	Adj. MS	F-Value	P-Value
Type of alarm	1	14.64	14.644	20.69	0.000
Distance	20	2122.38	106.119	149.93	0.000
Error	20	14.16	0.708		
Total	41	2151.18			

Moving Forward

This study provided evidence that could be utilized as a guideline or framework for regulatory bodies and car manufacturers to establish a productive CPD system that effectively alerts drivers about locked children in cars. It is concluded from the findings that the multi-tone low-frequency alarm is superior to the single-tone high-frequency alarm. The frequency and type of alarm significantly affect the sound pressure level at any distance (p-value < 0.05), which was found through ANOVA analysis. Although the single-tone alarm can be heard louder at shorter distances, it still needs to be more effective since it is difficult to recognize in a high background noise environment. This study was limited to two types of alarm, which are single-tone and multi-tone. Hence, future studies should include broadband-type alarms and compare low- and high-frequency alarms for the three-alarm types.

ACKNOWLEDGMENT

The authors would like to acknowledge the support from ASEAN NCAP (MIROS) under grant number 9025-00015. Furthermore, the authors acknowledge the staff at the Center of Excellence Automotive and Motorsport and Faculty of Mechanical Engineering Technology, Universiti Malaysia Perlis (UniMAP), and MIROS officials for their productive discussions and input to the research.

REFERENCES

Abdullah, S., Fuad, M. F. A., Dom, N. C., Ahmed, A. N., Yusof, K. M. K. K., Zulkifli, M. F. R., ... & Ismail, M. (2021). Effects of environmental noise pollution towards school children. Malaysian Journal of Medicine & Health Sciences, 17(3), 38-44.

Barbosa, A. A. R., & Bertoli, S. R. (2017). Standard load conditions for sound levels measurement in portable saw operations: A proposed model. MOJ Civil Eng., 2(2), 00029.

Carmel, D., Yeshurun, A., & Moshe, Y. (2017). Detection of alarm sounds in noisy environments. In 2017 25th European Signal Processing Conference (EUSIPCO) (pp. 1839-1843). IEEE.

Katalin, Á. (2018). Studying noise measurement and analysis. Procedia Manufacturing, 22, 533-538.

Kouno, F., & Ishimaru, R. (2017). Development of automatic evaluation system for vehicle alarm. Denso Ten Technical Review, 1, 72-75.

Laroche, C., Giguère, C., Vaillancourt, V., Roy, K., Pageot, L. P., Nélisse, H., Ellaham, N. & Nassrallah, F. (2018). Detection and reaction thresholds for reverse alarms in noise with and without passive hearing protection. International Journal of Audiology, 57(sup1), S51-S60.

Popoff-Asotoff, P., Holgate, J., & Macpherson, J. (2012). Which is safer – Tonal or broadband reversing alarms? In Proceedings of Acoustics.

Rabaglia, C. D., Maglio, S. J., Krehm, M., Seok, J. H., & Trope, Y. (2016). The sound of distance. Cognition, 152, 141-149.

Rosli, M. M. H., Afandi, N. I., Leah, P. J. Y., Joli, N. S., Kassim, K. A., & Mansor, M. R. A. (2019). A review of unattended child presence detection system for ASEAN NCAP safety rating. Journal of the Society of Automotive Engineers Malaysia, 3(1), 28-37.

Salleh, I., Zain, M. M., & Hamzah, R. R. (2013). Evaluation of annoyance and suitability of a back-up warning sound for electric vehicles. International J. of Automotive and Mechanical Engineering, 8, 1267-1277.

Segaran, V. C., Tong, Y. G., Abas, N. H., Azni, N. I., & Zairuddin, M. A. (2019). Assessment of traffic noise pollutions outside school, residential, hospital and commercial areas along Jalan Kluang, Batu Pahat, Johor. International Journal of Integrated Engineering, 11(9), 123-131.

Segaran, V. C., Tong, Y. G., Abas, N. H., Daniel, B. D., Nagapan, S., & Kelundapyan, R. (2020). Traffic noise assessment among residential environment in Batu Pahat, Johore, Malaysia. In IOP Conference Series: Materials Science and Engineering (Vol. 713, No. 1, p. 012049). IOP Publishing.

Vaillancourt, V., Nélisse, H., Laroche, C., Giguère, C., Boutin, J., & Laferrière, P. (2013). Comparison of sound propagation and perception of three types of backup alarms with regards to worker safety. Noise and Health, 15(67), 420-436.