4단계 BK21사업 자율주행 xEV 혁신 인재 교육연구단

국제학술대회 사전계획서

학회명	Inter-noise 2023		
개최국	일본	개최장소	도쿄
신청인	류동규	학번	A2022009
지도교수	신성환	동행 여부	동행
논문 제목	Factor affecting dynamic feeling of vehicle sound related to firing-order component and its effect		
참가목적	논문 발표, 학술 교류		
BK사업과의 연구 관련성	xEV의 Active Sound Design(Generating)의 기초가 되는 내용 연구		

1. 일정 세부 계획안

NO	날짜	세부일정	활동내역
1	08.19	일본 도착 숙소로 이동 참석 희망 세션 논문 스터디 발표 대본 검토 및 리허설	출발 및 일본 도착(~12:35) 점심 식사 및 숙소 이동 참석 희망 세션 논문 스터디 및 토의(~18:00) 발표 대본 검토 및 리허설(~21:00)
2	08.20	학회 참석 1일차 참석 희망 세션 논문 스터디 발표 자료 검토 및 리허설 개회식 참석 Plenary Lecture 수강	개인별 참석 희망 세션 논문 스터디(~12:00) 발표자료 검토 및 리허설(~15:00) 학회장 이동 개회식 참석(16:00~17:00) Plenary Lecture: Sound in Life and Acoustics for Society 수강(17:00~18:00)
3	08.21	학회 참석 2일차 세션 참가 및 학술 교류 포스터 발표 참관	Keynote lecture: Underwater Acoustics and Marine System 수강(08:20~09:20)

			05. Active Control of Sound & Vibration | Poster Session 참석(09:40~12:20) 포스터 발표 참관(한승연) 점심 식사(~13:20) Keynote lecture: Exploring Real-World Geometry Effects on Airfoil and Bluff-Body Flow Noise 수강(13:20~14:20) 07.3 Airport Noise 세션 참석(14:20~18:00)
4	08.22	학회 참석 3일차 세션 참가 및 학술 교류 논문 구두 발표	Keynote lecture: The Short Story of Urban Acoustics 수강(08:20~09:20) 15.2 세션 참석(09:40~12:00) 구두 발표(류동규) 점심 식사(~13:20) 08.2 Interior Noise & Sound Design 세션 참석(14:40~15:40) 15.0 Sound Quality & Product Noise: General 세션 참석(16:00~18:20)
5	08.23	학회 참석 4일차 세션 참가 및 학술 교류 귀국	07.7 Urban Air Mobility Community Noise 세션 참가(08:40~10:00) 07.7 Urban Air Mobility Community Noise 세션 참가(10:20~12:00) 점심 식사(12:20~13:20) 15.1 Psychological & Physiological Evaluation of Product Noise 세션 참가(13:20~15:00) Plenary lecture: Committing to Full-Spectrum Noise Equity 수강(15:20~16:20) 공항 이동 귀국 및 귀가(18:20~)

2. 예산계획안

일련 번호	지원 항목	계산내역	지원신청액	비고
1	학회등록비	16,800JPY= 171,309 대한민국 원	171,309 원	
2	항공비	595,200 대한민국 원	595,200 원	
3	숙박비	$ 140 * 4박 = $ 560 730,307 대한민국 원	730,307 원	
4	일비	$ 30 * 5일 = $ 150 195,617 대한민국 원	195,617 원	
5	기타			
합 계			1,692,433 원	

위의 건에 대하여 사전 계획서를 제출합니다.

2023년 07월 11일

자율주행 xEV혁신인재 교육연구단장 귀하

신 청 인 : 류 동 규 (인) 참 여 교 수 : 신 성 환 (인)	결 재	담 당	검 토	부단장	연구단장

BrainKorea21 FOUR

REGISTRATION FEES

(in JPY)

	Up to May 29	Up to July 21	After July 22
Regular participant	81,200	86,800	92,400
Student	16,800		22,400
Accompanying person	16,800		
Additional paper	8,400		

※Up to May 29: Early bird, Up to July 21: Regular, After July 22: Registration can only be made at the venue

The registration fees apply whether an on-site or online delegate.

For **On-site delegates**, Registration Fee includes the following items:

– All conference materials

– Access to all scientific sessions, exhibition

– Refreshment breaks

– Access to online livestreams and recorded presentations.

For **Online delegates**, registration fee includes the following items:

– Access to 8 live streams (opening and closing ceremony, 2 plenary and 4 keynote presentations) directly from Inter-Noise 2023 from the International Conference Room.

– Access to the recordings of the presentations of the technical sessions. (recordings will be available within approximately 24 hours after the congress has taken place).

Registration Fees are in JPY and include VAT @ 10%

Receipt

Issued Date Jul. 7, 2023
Date of Order Feb. 10, 2023
No. A00729

Received from Dongkyu Lew

The below sum has been duly received.

Method of Payment	Credit-card payment
Received Payment on	May. 9, 2023

Inter-Noise 2023
Congress President Shinichi Sakamoto

Amount	16,800 JPY

Classification / Items		Unit	Order	Amount
Inter-Noise 2023 Registration Fee	Student (up to July 21)	16,800 JPY	1	16,800 JPY
Additional Papers	No additional papers	0 JPY	1	0 JPY
Accompanying Persons	No: Unaccompanied	0 JPY	2	0 JPY
Banquet [CLOSED]	No: Not Attend	0 JPY	1	0 JPY
			Total	16,800 JPY

Received for Inter-Noise 2023 expenses.

우리카드

국외이용 매입조회

성　명 : 국민대학교산학협력단

접 수 기 간 : 2023-05-01 ~ 2023-05-31

순번	카드번호 / 가맹점명	매출일자 / 매입일자	매출종류 / MCC	이용금액(현지) 현지통화	이용금액(현지) 국가	이용금액(USD) / 적용환율	이용금액(원화) / 승인번호	해외이용수수료 / 현금이용수수료	청구금액 / 결제일자
1	5584-20**-*****-0790	2023-05-09	일시불		16,800.00	126.10	170,802	507	171,309
	INTERNOISE2023	2023-05-15	5964	일본 엔	일본	1,354.50	646318	0	2023-06-23
2	5584-20**-*****-0790	2023-05-09	일시불		16,800.00	126.10	170,802	507	171,309
	INTERNOISE2023	2023-05-15	5964	일본 엔	일본	1,354.50	646545	0	2023-06-23
3	5584-20**-*****-0790	2023-05-11	일시불		81,200.00	610.98	823,845	2,447	826,292
	INTERNOISE2023	2023-05-16	5964	일본 엔	일본	1,348.40	745212	0	2023-06-23

총건수	미화환산금액 합계(USD)	원화환산금액 합계	해외이용수수료 합계	현금수수료 합계	청구금액 합계
3	863.18	1,165,449	3,461	0	1,168,910

영수증 인쇄하기

KOREAN AIR

카드종류 / Card Type CA	거래유형 / Form of Payment Credit Card
카드번호 / Card No. ************0790	
유효기간 / Expiry Date **/**	거래일자 / Approval Date 11MAY2023
항공권번호 / Ticket No. 1802336846187	
승객 / Passenger LEW/DONGKYU MR	
지불운임 / Fare KRW 475,000	여정 / Itinerary ICN-NRT-ICN
Taxes and Fuel SurCharge 세금 / Taxes KRW 64,200 유류할증료 / Fuel SurCharge KRW 56,000	예약번호 / Booking Reference 17054386
	할부기간 / Installment 일시불
	승인번호 / Approval No. 50102095
	가맹점명 / Merchant Name (주)대한항공(Korean Air)
결제금액 / Payment Amount KRW 595,200	대표자 / President 우기홍 외 1명

가맹점 주소 / 서울특별시 강서구 하늘길 260 (공항동)
Address / 260, Haneul-gil, Gangseo-gu, Seoul, Korea

사업자등록번호 / Business Registration No.
110-81-14794

KOREAN AIR e-티켓 확인증
e-Ticket Itinerary & Receipt

1338 / 11MAY2023

승객성명 Passenger Name	항공권번호 Ticket Number	예약번호 Booking Reference
LEW/DONGKYU MR (KE11261935****)	**1802336846187**	**17054386** (6F8QTB)

여정 Itinerary

출발 From	도착 To	편명 Flight
ICN **서울/인천(Incheon)** **19AUG2023(토) 10:10** (Local Time) Terminal No : 2	**NRT** **도쿄(Tokyo Narita Intl)** **19AUG2023(토) 12:35** (Local Time) Terminal No : 1	**KE 703** Operated by KE KOREAN AIR

대한항공은 인천공항 제 2 여객터미널에서 운항합니다.

예약등급 Class : M (일반석)	예약상태 Status : OK (확약)	좌석번호 Seat number : 28B
운임 Fare Basis : MLE0ZRKN	수하물 Baggage : **1 Piece**	항공권 유효기간 Validity : -19AUG2024
기종 Aircraft Type : Airbus A330-300	비행시간 Flight Duration : 02H 25M	SKYPASS 마일리지 SKYPASS Miles : 758

출발 From	도착 To	편명 Flight
NRT **도쿄(Tokyo Narita Intl)** **23AUG2023(수) 18:20** (Local Time) Terminal No : 1	**ICN** **서울/인천(Incheon)** **23AUG2023(수) 20:55** (Local Time) Terminal No : 2	**KE5744** Operated by LJ0204 JIN AIR

JIN AIR 항공기로 운항하는 공동운항편입니다. JIN AIR의 터미널과 탑승수속 카운터를 이용하시기 바라며 모바일/웹 체크인은 운항 항공사 홈페이지에서 확인 하시기 바랍니다. 운항 항공사 규정에 따라 탑승수속 마감시간이 다를 수 있으니 반드시 확인하시기 바랍니다.

예약등급 Class : B (일반석)	예약상태 Status : OK (확약)	좌석번호 Seat number :
운임 Fare Basis : BNE0ZLKJ	수하물 Baggage : **1 Piece**	항공권 유효기간 Validity : -19AUG2024
기종 Aircraft Type : Boeing 777-200ER	비행시간 Flight Duration : 02H 35M	SKYPASS 마일리지 SKYPASS Miles : 758

- 스케줄, 기종 및 좌석등급(서비스클래스)는 부득이한 사유로 사전 예고없이 변경될 수 있습니다. 또한 항공기 교체등의 부득이한 사유로 선택하신 좌석이 변경될 수 있으니 탑승수속 시 기종 및 좌석번호를 재확인해 주시기 바랍니다.

	August 20 (Sun)	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00
	Venue											
1	Int'l Conf Rm (2F)									Opening	Plenary 1	
9	Rm 201A									Live Streaming		
10	Rm 201B									Live Streaming		

	August 21 (Mon)	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00
	Venue											
1	Int'l Conf Rm (2F)	Keynote 1	18.1		18.1		Keynote 2	18.1		18.1		
2	Rm 101A		02.1		02.1			02.2		02.0		
3	Rm 101B		11.5		11.5			11.5		15.3		
4	Rm 102A		09.1		09.0			09.0		05.1		
5	Rm 102B		03.4		03.4			03.2		03.2		
6	Rm 103		01.0		01.0			01.0		01.0		
7	Rm 104		03.0		03.0			03.0		03.0		
8	Rm 105		04.0	Break	04.0			04.1		Break, 04.1		
9	Rm 201A		06.3		06.4	Lunch		06.4		06.1		
10	Rm 201B		13.3		13.3			07.3		07.3		
11	Rm 202		12.0		12.1			12.1		13.1		
12	Rm 301A		08.3		08.1			08.1		08.1		
13	Rm 301B		11.0		11.0			11.1		11.1		
14	Rm 302		12.8		12.8			12.5		12.5		
15	Rm 303		14.0		14.1			14.2		14.1		
16	Rm 304		16.0		16.1			16.1		16.3		
P	Lobby (2F)			Poster:01-05					Poster:06-10			

	August 22 (Tue)	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00
	Venue											
1	Int'l Conf Rm (2F)	Keynote 3					Keynote 4	Banquet Preparation				
2	Rm 101A		02.2		02.3			02.0		01.2		
3	Rm 101B		05.0		05.0			05.3		05.3		
4	Rm 102A		13.4		13.4			10.1		10.1		
5	Rm 102B		06.5		06.5			07.2		07.2		
6	Rm 103		01.1		01.1			01.1		01.1		
7	Rm 104		03.2		03.1			03.1		03.1		
8	Rm 105		04.4	Break	04.1			04.2	Break	04.2		
9	Rm 201A		06.2		06.2	Lunch		06.2		06.6		
10	Rm 201B		07.4		07.4			07.5		07.5		
11	Rm 202		15.2		15.2			08.2		15.0		
12	Rm 301A		13.2		13.2			08.0		08.0		
13	Rm 301B		12.6		12.6			11.1		11.1		
14	Rm 302		12.9		12.9, 12.2			12.2		12.2		
15	Rm 303		14.5		14.3			14.3		14.3		
16	Rm 304		16.2		16.2			13.0		13.0		
P	Lobby (2F)			Poster:11-12					Poster:13-17			

	August 23 (Wed)	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00
	Venue											
1	Int'l Conf Rm (2F)			18.2			18.2		Plenary 2	Closing		
2	Rm 101A	12.4		12.3			12.3					
3	Rm 101B	05.2		05.2			05.2					
4	Rm 102A		10.2	10.2	10.3		10.3					
5	Rm 102B	07.1		07.1			07.6					
6	Rm 103	01.2		01.3			01.3					
7	Rm 104		03.3	03.3			03.3					
8	Rm 105	04.3		Break, 04.3	04.5		04.5					
9	Rm 201A	06.3		06.3		Lunch	15.1		Break			
10	Rm 201B	07.7		07.7			11.3					
11	Rm 202	17.0		15.4			17.0					
12	Rm 301A	08.2		08.0			08.0					
13	Rm 301B	11.4		11.2			11.2					
14	Rm 302	12.9		12.7			12.7					
15	Rm 303	14.4		14.6			14.6					
16	Rm 304	16.5		14.5			16.4					

Areas	Sessions
01. Flow-induced Noise & Vibration	01.0 Flow-induced Noise & Vibration: General
	01.1 Computational Methods in Flow-induced Noise & Vibration
	01.2 Experiments in Flow-induced Noise & Vibration
	01.3 Rotor & Turbomachinery Noise
02. Vibro-acoustics	02.0 Vibro-acoustics: General
	02.1 Numerical Methods in Vibro-acoustics
	02.2 Vibro-acoustics Experiments
	02.3 Application of Vibro-acoustics Methods to Noise Control
03. Signal Processing & Measurements	03.0 Signal Processing & Measurements: General
	03.1 Microphone Array Techniques
	03.2 Spatial Capture & Reproduction
	03.3 Measurement Instrumentation
	03.4 Measurement Standard
04. Modeling & Numerical Simulation	04.0 Modeling & Numerical Simulation: General
	04.1 Room Acoustics Modeling & Simulation
	04.2 Vibration Analysis
	04.3 Numerical Techniques in Acoustics & Vibration
	04.4 Sound Source Modeling
	04.5 Sound Propagation Modeling & Simulation
05. Active Control of Sound & Vibration	05.0 Active Control of Sound & Vibration: General
	05.1 Active & Passive Noise Control
	05.2 Signal Processing & Algorithms for ANC
	05.3 New Applications of Active Control
06. Transportation Noise & Vibration	06.1 Railway Vehicle Acoustics
	06.2 Railway Noise
	06.3 Tire & Road Noise
	06.4 Noise Barriers & Mitigation Techniques
	06.5 Road Traffic Noise Calculation Methods
	06.6 Road Vibrations: Predictions, Measurements & Mitigation Measures
07. Aircraft Noise	07.1 Aircraft Interior Noise
	07.2 Aircraft Exterior Noise
	07.3 Airport Noise
	07.4 Airport Noise Modeling & Mapping
	07.5 Advanced Monitoring & Measurement
	07.6 Supersonic Aircraft Noise
	07.7 Urban Air Mobility Community Noise
08. Vehicle Noise & Vibration	08.0 Vehicle Noise & Vibration: General
	08.1 Pass-by Noise, Tire & Pavement
	08.2 Interior Noise & Sound Design
	08.3 Noise & Vibration of Electric, Hybrid & Alternative Powertrains
09. Industrial Noise	09.0 Industrial Noise: General
	09.1 Wind Turbine Noise
10. Underwater & Maritime Acoustics	10.1 Target Detection & Classification
	10.2 Measurement & Control of Ship Noise
	10.3 Effect of Noise on Aquatic Animals & Noise Exposure Criteria
11. Acoustic Materials	11.0 Acoustic Materials: General
	11.1 Acoustic Metamaterials
	11.2 Microperforated Materials
	11.3 Sound Absorbers & Diffusers
	11.4 Additive Manufacturing for Acoustic Applications
	11.5 Sound Absorption Measurements

Areas	Sessions
12. Building & Architectural Acoustics	12.0 Building & Architectural Acoustics: General
	12.1 Requirements, Classification Schemes & Standards in Building Acoustics
	12.2 Impact & Structure-borne Sound in Buildings
	12.3 Ventilation-enabling Sound Insulation Devices
	12.4 Building System Noise & Vibration Control
	12.5 Sound Insulation Measurement & Prediction
	12.6 Sound Insulation of Wooden Buildings
	12.7 Acoustics of Education Spaces
	12.8 Acoustics of Workspaces
	12.9 Acoustics in Indoor Spaces
13. Environmental Noise	13.0 Environmental Noise: General
	13.1 Noise Mapping
	13.2 Smart Cities & Noise Monitoring
	13.3 Outdoor Noise Propagation
	13.4 Low-frequency Sound
14. Perception & Health	14.0 Perception & Health: General
	14.1 Community Response to Noise
	14.2 Noise & Health
	14.3 Psychoacoustics of Noise Evaluation & Universal Design
	14.4 Physiological & Emotional Responses to Environment Sound
	14.5 Occupational Noise & Hearing Loss
	14.6 Response to Noise & Vibration
15. Sound Quality & Product Noise	15.0 Sound Quality & Product Noise: General
	15.1 Psychological & Physiological Evaluation of Product Noise
	15.2 Product Sound Quality
	15.3 Information Technology Equipment Noise
	15.4 Sound Design Based on Psychoacoustics
16. Soundscapes	16.0 Soundscapes: General
	16.1 Soundscape Evaluations: Towards the Development of Standards
	16.2 Outdoor Soundscape Planning & Design, and Urban Design
	16.3 Indoor Soundscape Planning & Design
	16.4 Soundscape Preservation
	16.5 Artificial Intelligence & Machine Learning on Soundscape
17. Noise Policy & Management	17.0 Noise Policy & Management: General
18. Theme-related & Novel Approaches	18.1 Inclusive Design of Sound Environment
	18.2 Diversity of Local Noise Issues in the World

Factor affecting dynamic feeling of vehicle sound related to firing-order component and its effect

Dongkyu Lew[1]
Kookmin University
77, Jeongneung-ro, Seongbuk-gu, Seoul, Republic of Korea

Suho Cha[2]
Keyang Electric Machinery Co., Ltd.
9 Sandan-ro, Danwon-gu, Ansan-si, Gyeonggi-do, Republic of Korea

Sung-hwan Shin[3]
Kookmin University
77, Jeongneung-ro, Seongbuk-gu, Seoul, Republic of Korea

ABSTRACT

As consumers' expectations for the perceptional feeling of vehicles increase, the studies on sound design to improve the dynamic feeling have been actively conducted. The purpose of this study is to propose relevant factors to improve dynamics without reducing pleasantness. To this end, subjective tests were conducted to evaluate dynamic and comfortable feelings on the noises during the acceleration of two comparison vehicles. A factor based on the TNR *(tone-to-noise ratio) of ISO7779,* TNR_{order} *was extracted that could represent the feature of tonality of non-stationary signals. A vehicle having high* TNR_{order} *related to the first firing-order exhibited a strong dynamic feeling. It was also investigated that dynamic feeling could be increased after changing the* TNR_{order} *of the first- and second firing order components of the test vehicle through subjective test.*

1. INTRODUCTION

In a previous study, it was investigated the time-frequency distribution of acoustic signals in the vehicle cabin to identify the factors influencing acoustical dynamic feeling[1]. The vehicles employed in the research are a Prototype (P) vehicle, requiring improvements in acceleration dynamics, and a Target (T) vehicle, distinguished by its exceptional acceleration dynamics. The results revealed a significant difference in the tonality of the first firing order component between the T and P vehicles. To quantify this difference, a TNR_{order} calculation, which utilizes the Tone to Noise Ratio (TNR) calculation from ISO 7779, was introduced to assess the tonality of non-stationary signals such as acceleration sounds [2]. As using the previous research[3], this study presents a virtual sound generation system aimed at enhancing driving pleasantness by controlling the timing and adjusting the tone of virtual sounds to match the driving situation in Chap. 2. The virtual sound generation system employs active sound design (ASD) technology[4,5] and incorporates driving condition-specific virtual sound control logic in Chap. 3. As finally, it is investigated whether the TNR_{order} of engine sound is crucial for improving dynamics or not.

[1] dglew2002@kookmin.ac.kr
[2] shcha21@keyang.co.kr
[3] soulshin@ kookmin.ac.kr

2. PROPOSING A VIRTUAL SOUND GENERATION SYSTEM

2.1. Proposing Virtual Sound Control Timing and Components

It is necessary to improve dynamic feeling in the accelerated driving condition while maintaining pleasantness in other driving conditions [6,7]. Therefore, it can be suggested to limit that virtual sounds is only generated during accelerating vehicle The virtual sound component consists of the first firing order component (F_{1st}) [8], which is typically the most prominent component of engine sound. Additionally, the second firing order component (F_{2nd}), which corresponds to an octave relationship with F_{1st}, is included. Excessive increase of F_{1st} to maximize dynamics can lead to decrease the pleasantness, and so we proposed that the timbre change effect of F_{2nd} can address this issue [2].

2.2. Editing Virtual Sound Levels

2.2.1 Increasing the level of the engine order component

In this study, we utilize a peak filter [9,10] to increase the level of the engine order component. The half-power bandwidth (BW_{-3dB}) is calculated for F_{1st}, which is the most frequently occurring engine order component. Examining the distribution of BW_{-3dB} according to driving conditions, we found that BW_{-3dB} of P vehicle:8.85 Hz, BW_{-3dB} of T vehicle:9.85 Hz, and we set them as representative values as BW_{-3dB} of the peak filter as aiming to minimize the inconsistency of the sound source caused by the increase in the order component, while reflecting the characteristics of the original sound source. Regarding the parameters of the peak filter, we set the center frequency (f_c) to frequency of F_{1st}, and set the BW_{-3dB} to 8.85 Hz, which is representative value of P vehicle, and the gain to 10 dB.

2.2.2 Increasing TNR_{order}

To increase the TNR_{order}, we aim to modify a sound source with varying levels of order components by establishing target level criteria for F_{1st} and F_{2nd} using acceleration curves. By applying a peak filter and adjusting the gain, the $TNR_{F_{1st}}$ level is varied based on the $TNR_{F_{1st}}$ uniform increase level line. $TNR_{F_{2nd}}$ is increased in accordance with the throttle opening amount [11] to capture the driving characteristics and account for the timbre change effect during acceleration. The same method used for $TNR_{F_{1st}}$ is employed to meet the target level for $TNR_{F_{2nd}}$.

3. EVALUATION OF ORDER COMPONENT IMPROVEMENT AND VIRTUAL SOUND DESIGN

For vehicle P, we conducted a subjective evaluation of dynamics and pleasantness [12]. The evaluation was divided into two parts: the assessment of the improvement in the first firing order (F_{1st}) to identify the effect of the enhancement of dynamic feeling, and the evaluation of the improvement in the second firing order (F_{2nd}) to identify the same effect.

3.1. Proposing Virtual Sound Control Timing and Components

3.1.1 Construction of Subjective Evaluation

In this paper, the evaluation process made use of a single sound source to a limited extent: the original sound corresponding to 100km/h-WOT(Wide-Open Throttle), which are necessary for generating the F_{1st} virtual sound of the P vehicle, and the sound source edited with F_{1st} using a quantitative method to increase the level of $TNR_{F_{1st}}$. The sound source edited to the target level of $TNR_{F_{1st}}$ (referred to as the "primary edited sound source") was labeled with an "F" prefix indicating the editing percentage relative to the target level of 100%. The evaluation feelings were dynamics and pleasantness, both rated on a scale of 1 to 9 with intervals of 0.5 points. 19 juries in their 20s and 30s with normal hearing participated in the experiment, and the subjective results were expressed as the mean and 95% confidence interval.

3.1.2 Subjective Evaluation Results

In order to assess the enhancement of dynamics through the increase of F_{1s} , the evaluation results of the original sound source and the primary edited sound source were compared based on driving conditions, as shown in Figures 1. The sound source that exhibited a notable improvement in the sense of dynamics during the initial section of acceleration for the driving condition was selected: F60% for 100km/h-WOT, demonstrating an enhancement of at least 0.5 points in the evaluation score. Through the results of F60% and F80% for 100 km/h-WOT, the dynamics of modified sound(primary edited sound) is rated highly than original sound.

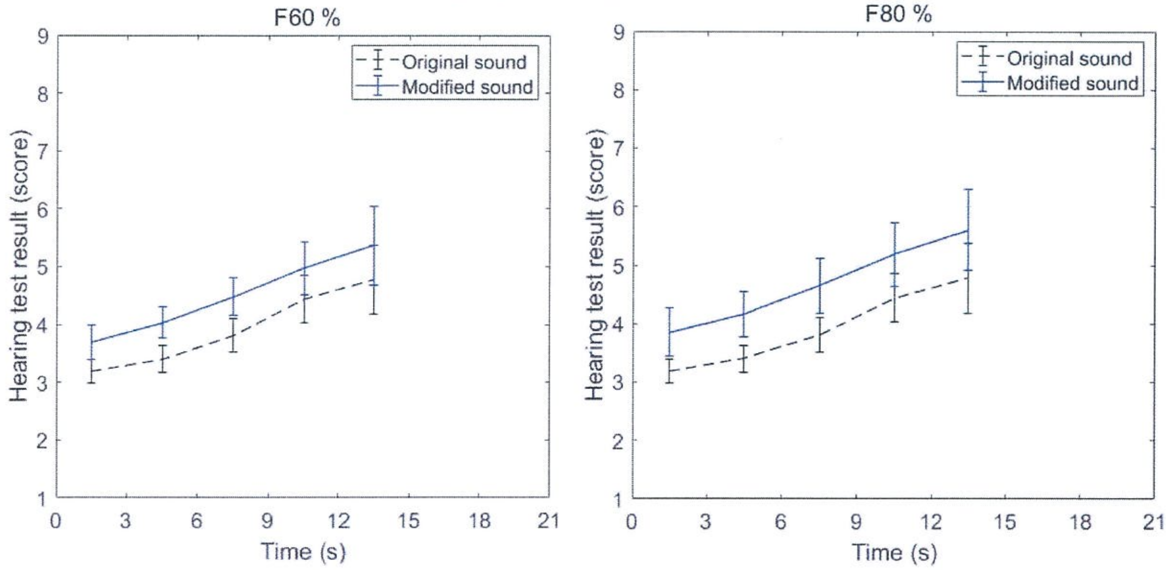

Figure 1: Dynamics evaluation results at 100 km/h-WOT.

Next, we analyzed the changes in pleasantness resulting from the increase in F_{1s} . The pleasantness evaluation result of the original sound and the primary edited sound source based on driving condition shown in Figures 2, the rating of edited sound was lower than the original one. Furthermore, it can be observed that the difference in pleasantness compared to the original sound source becomes noticeable when F_{1st} is increased beyond a certain level.

For 100 km/h-WOT, the pleasantness rating of F80% is lower than the scores of original sound and F60%, and is rated below 4 from 6 to 9 seconds. We analyzed the sound pressure level and loudness of the primary edited sound source and we found that the sound pressure level and loudness of the segments with a score of 4 or less were high, 72 to 75 dB and 28 to 34 sone, respectively.

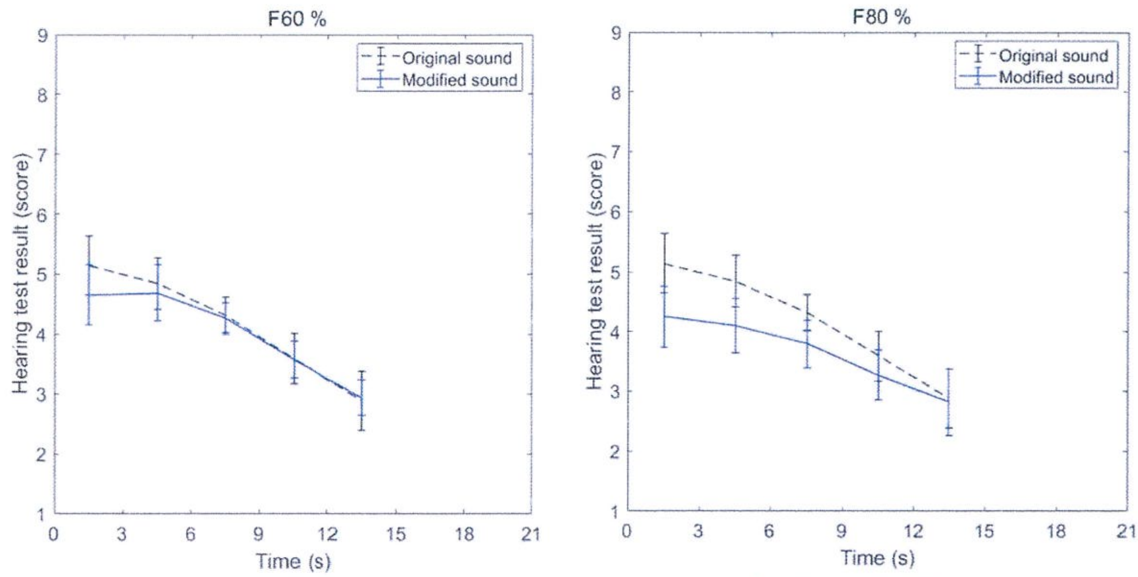

Figure 2: Pleasantness assessment results at 100 km/h-WOT.

3.1.3 Setting the First Firing Order(F_{1st}) Level
In the above section, the results of the subjective evaluation regarding dynamics and pleasantness for the primary edited sound sources were analyzed. It was observed that for dynamics, the improvement over the original sound source occurred in F60% and F80% at 100 km/h-WOT during the initial phase of acceleration. Regarding pleasantness, specific sections of acceleration showed reductions from the original sound in F80% for 100 km/h-WOT. Therefore, F_{1st} was set to enhance dynamics compared to the original while maintaining pleasantness.

3.2 Evaluation of Secondary Firing Order Improvement

3.2.1 Structure of the Subjective Evaluation
In addition to the F_{1s} level-setting sound source, a secondary firing order improvement evaluation was conducted to assess the effect of increasing F_{2nd} in the acceleration section. The sound source for the secondary evaluation comprised the edited sound sources of F_{1st} and F_{2nd} using a method that allows for various levels of F_{2n} editing. For the F60% sound source, which achieved enhanced dynamics while maintaining pleasantness, the F_{2nd} editing level for the $TNR_{F_{2nd}}$ target level curve was indicated with "_S." This was conducted with the purpose of comparing the levels of dynamics and pleasantness when both F_{1st} and F_{2nd} were increased simultaneously.

3.2.2 Results of Subjective Evaluation
the dynamics accoreding to the chagne of the second firing order (F_{2nd}) were compared with the original sound in Figure 3. It can be observed that the dynamics of vehicle P (Figure 3-(a)) are higher than the preliminary test, whereas the dynamics of vehicle T (Figure 3-(b)) show the opposite trend, with a lower deviation from the preliminary test.

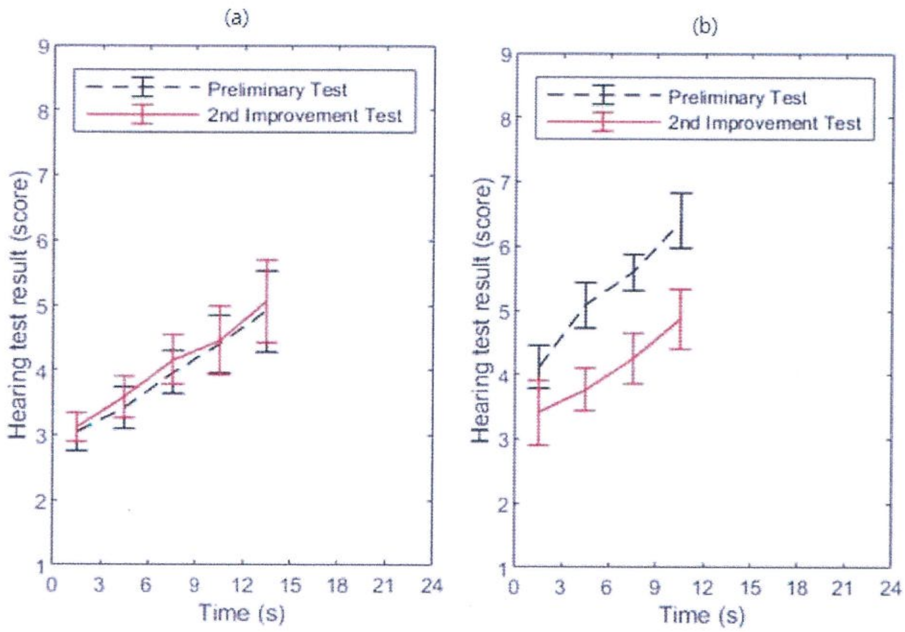

Figure 3: Comparison of dynamics evaluation results between the secondary evaluation sound source and the original vehicle sound source: (a) P-100km/h-WOT (b) T-100km/h-WOT.

To analyze the results of the secondary verification evaluation, Figure 4 display the original and secondary edited sound sources for both P and T vehicles. Overall, it is observed that dynamics increase as acceleration progresses, while pleasantness decreases as same as the first firing order improvement evaluation. Additionally, it can be noted that the difference in dynamics and pleasantness compared to the original sound occurs when F_{2n} is increased beyond a certain level, and dynamics are improved beyond the original sound of the T vehicle. We examined the change in pleasantness by adding F_{2nd} to the F_{1st} enhanced sound source. At 100km/h-WOT, the pleasantness rating of F60%_S6dB is significantly inferior with F60%_S3dB after 3~6 seconds segment. The sound pressure and loudness of F60%_S6dB are high same as the first firing order improvement evaluation. Therefore, it is evident that an increase in sound pressure level (or loudness) through the elevation of F_{2n} can significantly impact pleasantness, underscoring the importance of selecting an appropriate level of F_{2nd} that can enhance dynamics while maintaining pleasantness.

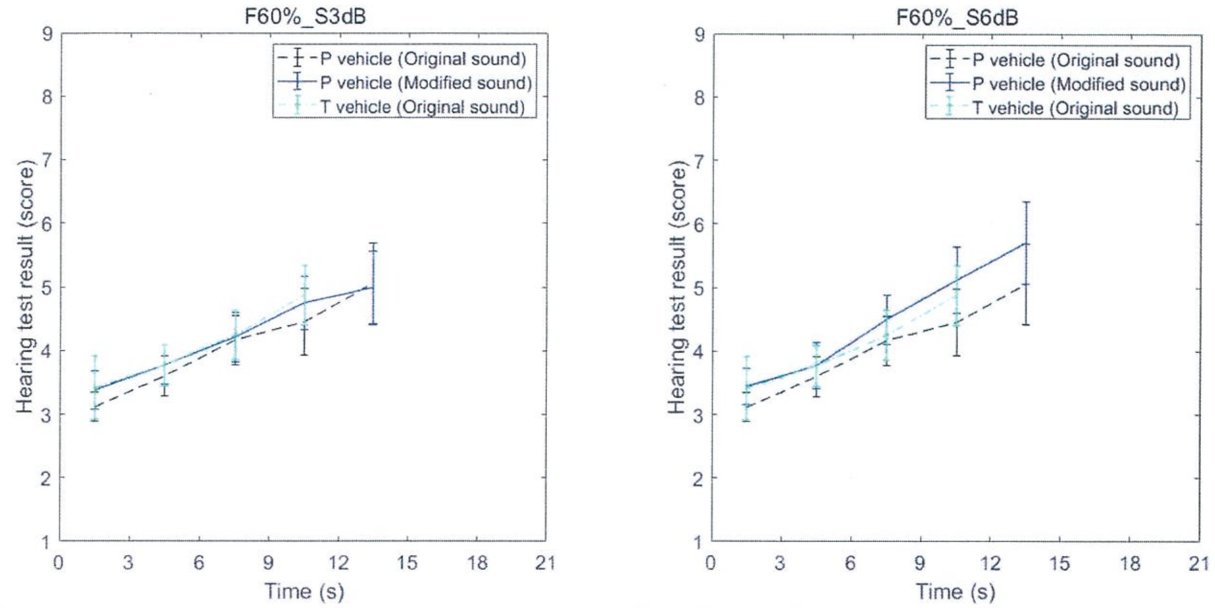

Figure 4: Dynamics according the change of Secondary Firing Order for the driving condition: 100 km/h-WOT.

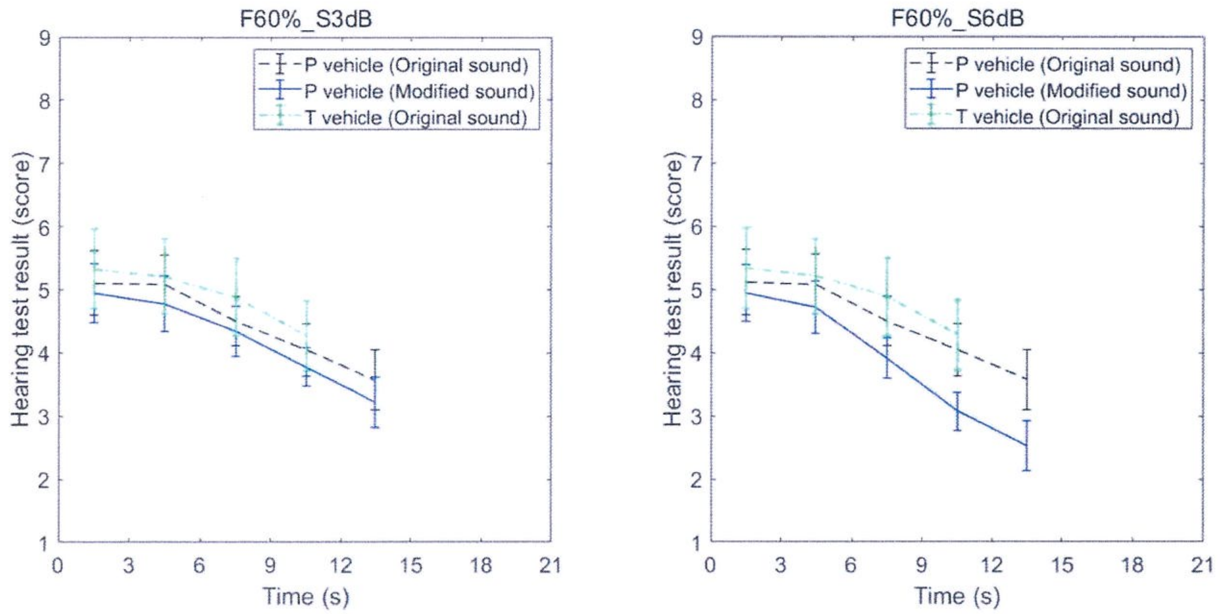

Figure 5: Pleasantness according the change of Secondary Firing Order for the driving condition: 100 km/h-WOT.

3.2.3 Setting the Secondary Firing Order (F_{2nd}) Level

At 100km/h-WOT, the dynamics already reached the level of the T vehicle with only F_{1st} increased, even at F60%. Moreover, at F60%_S6dB, the dynamics surpassed the T vehicle during a certain period. However, pleasantness decreased during the same acceleration period. Considering that the dynamics of F60%_S3dB rated higher than the original sound while maintaining the pleasantness, the secondary firing order (F_{2nd}) level was set at F60%_S3dB to minimize the increase in sound pressure level while satisfying the target level requirement.

4. CONCLUSION

Throughout the course of this research, vehicle signals and acoustic signals were collected for P and T vehicles with differing engine performance to investigate the acoustic factors that impact their acceleration performance and dynamics.

Based on the findings from the preliminary test, we investigated how enhancing the first(F_{1st}) and secondary firing order component(F_{2nd}) affects on dynamics and pleasantness of the P vehicle. Evaluation sound sources were generated by adjusting the degree of increase in the first firing order component with acceleration for the original sound source, and subjective evaluations were conducted using them. In the evaluation of the improvement in the first firing order (F_{1st}), the changes in dynamics and pleasantness compared to the original sound were identified. In the evaluation of the improvement in the second firing order (F_{2nd}), a secondary evaluation was conducted for the F_{1st} level-setting sound source selected in the first firing order (F_{1s}) improvement evaluation. It was found that modified sound sources displayed dynamics and pleasantness approaching or exceeding the performance of the T vehicle.

ACKNOWLEDGEMENTS

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4단계 BK21사업 자율주행 xEV 혁신 인재 교육연구단

국제학술대회 사전계획서

학회명	Inter-noise 2023		
개최국	일본	개최장소	도쿄
발표자	한승연	학번	A2022018
지도교수	신성환	동행 여부	동행
논문 제목	Active noise control performance in the high-frequency range		
참가목적	논문 발표, 학술 교류		
BK사업과의 연구 관련성	EV에서 발생하는 고주파 소음 제어를 위한 연구		

1. 일정 세부 계획안

NO	날짜	세부일정	활동내역
1	08.19	일본 도착 숙소로 이동 참석 희망 세션 논문 스터디 발표 대본 검토 및 리허설	출발 및 일본 도착(~12:35) 점심 식사 및 숙소 이동 참석 희망 세션 논문 스터디 및 토의(~18:00) 발표 대본 검토 및 리허설(~21:00)
2	08.20	학회 참석 1일차 참석 희망 세션 논문 스터디 발표 자료 검토 및 리허설 개회식 참석 Plenary Lecture 수강	개인별 참석 희망 세션 논문 스터디(~12:00) 발표자료 검토 및 리허설(~15:00) 학회장 이동 개회식 참석(16:00~17:00) Plenary Lecture: Sound in Life and Acoustics for Society 수강(17:00~18:00)
3	08.21	학회 참석 2일차 세션 참가 및 학술 교류 포스터 발표 참관	Keynote lecture: Underwater Acoustics and Marine System 수강(08:20~09:20)

			05. Active Control of Sound & Vibration | Poster Session 참석(09:40~12:20) 포스터 발표(한승연) 점심 식사(~13:20) Keynote lecture: Exploring Real-World Geometry Effects on Airfoil and Bluff-Body Flow Noise 수강(13:20~14:20) 07.3 Airport Noise 세션 참석(14:20~18:00)
4	08.22	학회 참석 3일차 세션 참가 및 학술 교류 논문 구두 발표	Keynote lecture: The Short Story of Urban Acoustics 수강(08:20~09:20) 15.2 세션 참석(09:40~12:00) 구두 발표 참관(류동규) 점심 식사(~13:20) 08.2 Interior Noise & Sound Design 세션 참석(14:40~15:40) 15.0 Sound Quality & Product Noise: General 세션 참석(16:00~18:20)
5	08.23	학회 참석 4일차 세션 참가 및 학술 교류 귀국	07.7 Urban Air Mobility Community Noise 세션 참가(08:40~10:00) 07.7 Urban Air Mobility Community Noise 세션 참가(10:20~12:00) 점심 식사(12:20~13:20) 15.1 Psychological & Physiological Evaluation of Product Noise 세션 참가(13:20~15:00) Plenary lecture: Committing to Full-Spectrum Noise Equity 수강(15:20~16:20) 공항 이동 귀국 및 귀가(18:20~)

2. 예산계획안

일련 번호	지원 항목	계산내역	지원신청액	비고
1	학회등록비	16,800JPY= 171,309 대한민국 원	171,309 원	
2	항공비	595,200 대한민국 원	595,200 원	
3	숙박비	$ 140 * 4박 = $ 560 730,307 대한민국 원	730,307 원	
4	일비	$ 30 * 5일 = $ 150 195,617 대한민국 원	195,617 원	
5	기타			
합 계			1,692,433 원	

위의 건에 대하여 사전 계획서를 제출합니다.

2023년 07월 11일

자율주행 xEV혁신인재 교육연구단장 귀하

신 청 인 : 한 승 연 (인) 참 여 교 수 : 신 성 환 (인)	결 재	담 당	검 토	부단장	연구단장

BrainKorea21 FOUR

Receipt

Issued Date Jul. 7, 2023
Date of Order Feb. 10, 2023
No. A00776

Received from Seoung Yeon Han

The below sum has been duly received.

Method of Payment	Credit-card payment
Received Payment on	May. 9, 2023

Inter-Noise 2023
Congress President Shinichi Sakamoto

Amount	16,800 JPY

Classification / Items		Unit	Order	Amount
Inter-Noise 2023 Registration Fee	Student (up to July 21)	16,800 JPY	1	16,800 JPY
Additional Papers	No additional papers	0 JPY	1	0 JPY
Accompanying Persons	No: Unaccompanied	0 JPY	1	0 JPY
			Total	16,800 JPY

Received for Inter-Noise 2023 expenses.

REGISTRATION FEES

(in JPY)

<table>
<tr><th></th><th>Up to May 29</th><th>Up to July 21</th><th>After July 22</th></tr>
<tr><td>Regular participant</td><td>81,200</td><td>86,800</td><td>92,400</td></tr>
<tr><td>Student</td><td colspan="2">16,800</td><td>22,400</td></tr>
<tr><td>Accompanying person</td><td colspan="3">16,800</td></tr>
<tr><td>Additional paper</td><td colspan="3">8,400</td></tr>
</table>

※Up to May 29: Early bird, Up to July 21: Regular, After July 22: Registration can only be made at the venue

The registration fees apply whether an on-site or online delegate.

For **On-site delegates**, Registration Fee includes the following items:

– All conference materials

– Access to all scientific sessions, exhibition

– Refreshment breaks

– Access to online livestreams and recorded presentations.

For **Online delegates**, registration fee includes the following items:

– Access to 8 live streams (opening and closing ceremony, 2 plenary and 4 keynote presentations) directly from Inter-Noise 2023 from the International Conference Room.

– Access to the recordings of the presentations of the technical sessions. (recordings will be available within approximately 24 hours after the congress has taken place).

Registration Fees are in JPY and include VAT @ 10%

우리카드

국외이용 매입조회

성 명 : 국민대학교산학협력단

접 수 기 간 : 2023-05-01 ~ 2023-05-31

순번	카드번호	매출일자	매출종류	이용금액(현지)		이용금액(USD)	이용금액(원화)	해외이용수수료	청구금액
	가맹점명	매입일자	MCC	현지통화	국가	적용환율	승인번호	현금이용수수료	결제일자
1	5584-20**-****-0790	2023-05-09	일시불		16,800.00	126.10	170,802	507	171,309
	INTERNOISE2023	2023-05-15	5964	일본 엔	일본	1,354.50	646318	0	2023-06-23
2	5584-20**-****-0790	2023-05-09	일시불		16,800.00	126.10	170,802	507	171,309
	INTERNOISE2023	2023-05-15	5964	일본 엔	일본	1,354.50	646545	0	2023-06-23
3	5584-20**-****-0790	2023-05-11	일시불		81,200.00	610.98	823,845	2,447	826,292
	INTERNOISE2023	2023-05-16	5964	일본 엔	일본	1,348.40	745212	0	2023-06-23

총건수	미화환산금액 합계(USD)	원화환산금액 합계	해외이용수수료 합계	현금수수료 합계	청구금액 합계
3	863.18	1,165,449	3,461	0	1,168,910

영수증 인쇄하기

KOREAN AIR

카드종류 / Card Type CA	거래유형 / Form of Payment Credit Card
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항공권번호 / Ticket No. 1802336846186	
승객 / Passenger HAN/SEOUNGYEON MS	
지불운임 / Fare KRW 475,000	여정 / Itinerary ICN-NRT-ICN
Taxes and Fuel SurCharge 세금 / Taxes KRW 64,200 유류할증료 / Fuel SurCharge KRW 56,000	예약번호 / Booking Reference 17054386 할부기간 / Installment 일시불 승인번호 / Approval No. 50102095 가맹점명 / Merchant Name (주)대한항공(Korean Air)
결제금액 / Payment Amount KRW 595,200	대표자 / President 우기홍 외 1명
가맹점 주소 / 서울특별시 강서구 하늘길 260 (공항동) Address / 260, Haneul-gil, Gangseo-gu, Seoul, Korea	
사업자등록번호 / Business Registration No. 110-81-14794	

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e-Ticket Itinerary & Receipt

1338 / 11MAY2023

승객성명 Passenger Name	항공권번호 Ticket Number	예약번호 Booking Reference
HAN/SEOUNGYEON MS	**1802336846186**	**17054386** (6F8QTB)

여정 Itinerary

출발 From	도착 To	편명 Flight
ICN **서울/인천(Incheon)** **19AUG2023(토) 10:10** (Local Time) Terminal No : 2	**NRT** **도쿄(Tokyo Narita Intl)** **19AUG2023(토) 12:35** (Local Time) Terminal No : 1	**KE 703** Operated by KE KOREAN AIR

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예약등급 Class : M (일반석)	예약상태 Status : OK (확약)	좌석번호 Seat number : 28A
운임 Fare Basis : MLE0ZRKN	수하물 Baggage : **1 Piece**	항공권 유효기간 Validity : -19AUG2024
기종 Aircraft Type : Airbus A330-300	비행시간 Flight Duration : 02H 25M	SKYPASS 마일리지 SKYPASS Miles : 758

출발 From	도착 To	편명 Flight
NRT **도쿄(Tokyo Narita Intl)** **23AUG2023(수) 18:20** (Local Time) Terminal No : 1	**ICN** **서울/인천(Incheon)** **23AUG2023(수) 20:55** (Local Time) Terminal No : 2	**KE5744** Operated by LJ0204 JIN AIR

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예약등급 Class : B (일반석)	예약상태 Status : OK (확약)	좌석번호 Seat number :
운임 Fare Basis : BNE0ZLKJ	수하물 Baggage : **1 Piece**	항공권 유효기간 Validity : -19AUG2024
기종 Aircraft Type : Boeing 777-200ER	비행시간 Flight Duration : 02H 35M	SKYPASS 마일리지 SKYPASS Miles : 758

- 스케줄, 기종 및 좌석등급(서비스클래스)는 부득이한 사유로 사전 예고없이 변경될 수 있습니다. 또한 항공기 교체등의 부득이한 사유로 선택하신 좌석이 변경될 수 있으니 탑승수속 시 기종 및 좌석번호를 재확인해 주시기 바랍니다.

	August 20 (Sun)	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00
	Venue										
1	Int'l Conf Rm (2F)									Opening	Plenary 1
9	Rm 201A									Live Streaming	
10	Rm 201B									Live Streaming	

	August 21 (Mon)	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00
	Venue										
1	Int'l Conf Rm (2F)	Keynote 1	18.1		18.1		Keynote 2	18.1		18.1	
2	Rm 101A		02.1		02.1			02.2		02.0	
3	Rm 101B		11.5		11.5			11.5		15.3	
4	Rm 102A		09.1		09.0			09.0		05.1	
5	Rm 102B		03.4		03.4			03.2		03.2	
6	Rm 103		01.0		01.0			01.0		01.0	
7	Rm 104		03.0		03.0			03.0		03.0	
8	Rm 105		04.0	Break	04.0			04.1		Break 04.1	
9	Rm 201A		06.3		06.4	Lunch		06.4		06.1	
10	Rm 201B		13.3		13.3			07.3		07.3	
11	Rm 202		12.0		12.1			12.1		13.1	
12	Rm 301A		08.3		08.1			08.1		08.1	
13	Rm 301B		11.0		11.0			11.1		11.1	
14	Rm 302		12.8		12.8			12.5		12.5	
15	Rm 303		14.0		14.1			14.2		14.1	
16	Rm 304		16.0		16.1			16.1		16.3	
P	Lobby (2F)			Poster:01-05					Poster:06-10		

	August 22 (Tue)	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00
	Venue										
1	Int'l Conf Rm (2F)	Keynote 3					Keynote 4	Banquet Preparation			
2	Rm 101A		02.2		02.3			02.0		01.2	
3	Rm 101B		05.0		05.0			05.3		05.3	
4	Rm 102A		13.4		13.4			10.1		10.1	
5	Rm 102B		06.5		06.5			07.2		07.2	
6	Rm 103		01.1		01.1			01.1		01.1	
7	Rm 104		03.2		03.1			03.1		03.1	
8	Rm 105		04.4		Break 04.1			04.2	Break	04.2	
9	Rm 201A		06.2		06.2	Lunch		06.2		06.6	
10	Rm 201B		07.4		07.4			07.5		07.5	
11	Rm 202		15.2		15.2			08.2		15.0	
12	Rm 301A		13.2		13.2			08.0		08.0	
13	Rm 301B		12.6		12.6			11.1		11.1	
14	Rm 302		12.9		12.9 12.2			12.2		12.2	
15	Rm 303		14.5		14.3			14.3		14.3	
16	Rm 304		16.2		16.2			13.0		13.0	
P	Lobby (2F)			Poster:11-12					Poster:13-17		

	August 23 (Wed)	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00
	Venue										
1	Int'l Conf Rm (2F)			18.2			18.2		Plenary 2	Closing	
2	Rm 101A	12.4		12.3			12.3				
3	Rm 101B	05.2		05.2			05.2				
4	Rm 102A		10.2	10.2	10.3		10.3				
5	Rm 102B	07.1		07.1			07.6				
6	Rm 103	01.2		01.3			01.3				
7	Rm 104		03.3	Break 03.3			03.3				
8	Rm 105	04.3		04.3	04.5		04.5				
9	Rm 201A	06.3		06.3		Lunch	15.1		Break		
10	Rm 201B	07.7		07.7			11.3				
11	Rm 202	17.0		15.4			17.0				
12	Rm 301A	08.2		08.0			08.0				
13	Rm 301B	11.4		11.2			11.2				
14	Rm 302	12.9		12.7			12.7				
15	Rm 303	14.4		14.6			14.6				
16	Rm 304	16.5		14.5			16.4				

Areas	Sessions
01. Flow-induced Noise & Vibration	01.0 Flow-induced Noise & Vibration: General
	01.1 Computational Methods in Flow-induced Noise & Vibration
	01.2 Experiments in Flow-induced Noise & Vibration
	01.3 Rotor & Turbomachinery Noise
02. Vibro-acoustics	02.0 Vibro-acoustics: General
	02.1 Numerical Methods in Vibro-acoustics
	02.2 Vibro-acoustics Experiments
	02.3 Application of Vibro-acoustics Methods to Noise Control
03. Signal Processing & Measurements	03.0 Signal Processing & Measurements: General
	03.1 Microphone Array Techniques
	03.2 Spatial Capture & Reproduction
	03.3 Measurement Instrumentation
	03.4 Measurement Standard
04. Modeling & Numerical Simulation	04.0 Modeling & Numerical Simulation: General
	04.1 Room Acoustics Modeling & Simulation
	04.2 Vibration Analysis
	04.3 Numerical Techniques in Acoustics & Vibration
	04.4 Sound Source Modeling
	04.5 Sound Propagation Modeling & Simulation
05. Active Control of Sound & Vibration	05.0 Active Control of Sound & Vibration: General
	05.1 Active & Passive Noise Control
	05.2 Signal Processing & Algorithms for ANC
	05.3 New Applications of Active Control
06. Transportation Noise & Vibration	06.1 Railway Vehicle Acoustics
	06.2 Railway Noise
	06.3 Tire & Road Noise
	06.4 Noise Barriers & Mitigation Techniques
	06.5 Road Traffic Noise Calculation Methods
	06.6 Road Vibrations: Predictions, Measurements & Mitigation Measures
07. Aircraft Noise	07.1 Aircraft Interior Noise
	07.2 Aircraft Exterior Noise
	07.3 Airport Noise
	07.4 Airport Noise Modeling & Mapping
	07.5 Advanced Monitoring & Measurement
	07.6 Supersonic Aircraft Noise
	07.7 Urban Air Mobility Community Noise
08. Vehicle Noise & Vibration	08.0 Vehicle Noise & Vibration: General
	08.1 Pass-by Noise, Tire & Pavement
	08.2 Interior Noise & Sound Design
	08.3 Noise & Vibration of Electric, Hybrid & Alternative Powertrains
09. Industrial Noise	09.0 Industrial Noise: General
	09.1 Wind Turbine Noise
10. Underwater & Maritime Acoustics	10.1 Target Detection & Classification
	10.2 Measurement & Control of Ship Noise
	10.3 Effect of Noise on Aquatic Animals & Noise Exposure Criteria
11. Acoustic Materials	11.0 Acoustic Materials: General
	11.1 Acoustic Metamaterials
	11.2 Microperforated Materials
	11.3 Sound Absorbers & Diffusers
	11.4 Additive Manufacturing for Acoustic Applications
	11.5 Sound Absorption Measurements

Areas	Sessions
12. Building & Architectural Acoustics	12.0 Building & Architectural Acoustics: General
	12.1 Requirements, Classification Schemes & Standards in Building Acoustics
	12.2 Impact & Structure-borne Sound in Buildings
	12.3 Ventilation-enabling Sound Insulation Devices
	12.4 Building System Noise & Vibration Control
	12.5 Sound Insulation Measurement & Prediction
	12.6 Sound Insulation of Wooden Buildings
	12.7 Acoustics of Education Spaces
	12.8 Acoustics of Workspaces
	12.9 Acoustics in Indoor Spaces
13. Environmental Noise	13.0 Environmental Noise: General
	13.1 Noise Mapping
	13.2 Smart Cities & Noise Monitoring
	13.3 Outdoor Noise Propagation
	13.4 Low-frequency Sound
14. Perception & Health	14.0 Perception & Health: General
	14.1 Community Response to Noise
	14.2 Noise & Health
	14.3 Psychoacoustics of Noise Evaluation & Universal Design
	14.4 Physiological & Emotional Responses to Environment Sound
	14.5 Occupational Noise & Hearing Loss
	14.6 Response to Noise & Vibration
15. Sound Quality & Product Noise	15.0 Sound Quality & Product Noise: General
	15.1 Psychological & Physiological Evaluation of Product Noise
	15.2 Product Sound Quality
	15.3 Information Technology Equipment Noise
	15.4 Sound Design Based on Psychoacoustics
16. Soundscapes	16.0 Soundscapes: General
	16.1 Soundscape Evaluations: Towards the Development of Standards
	16.2 Outdoor Soundscape Planning & Design, and Urban Design
	16.3 Indoor Soundscape Planning & Design
	16.4 Soundscape Preservation
	16.5 Artificial Intelligence & Machine Learning on Soundscape
17. Noise Policy & Management	17.0 Noise Policy & Management: General
18. Theme-related & Novel Approaches	18.1 Inclusive Design of Sound Environment
	18.2 Diversity of Local Noise Issues in the World

Active noise control performance in the high-frequency range

Seoung-Yeon Han[1], Sung-Hwan Shin[1], Chan-Hee Jeon[1], and Dong Kyu Lew[1]
Kookmin University
77, Jeongneung-ro, Seongbuk-gu, Seoul, Republic of Korea

Agustinus Oey[2] and Jiho Chang[2]
Vizwave lnc.
815, Daewangpangyo-ro, Sujeong-gu, Seongnam-si, Gyeonggi-do, Republic of Korea

Jangwon Lee[3] and Chang-Kook Chae[3]
Hyundai Motor Company
150, Hyundaiyeonguso-ro, Namyang-eup, Hwaseong-si, Gyeonggi-do, Republic of Korea

ABSTRACT

Noise control for vehicle mainly uses a reduction method through sound absorbing and insulating materials but has disadvantages of increasing cost and weight. It is known that the noise reduction performance of Active Noise Control (ANC) technology that can be considered as an alternative is limited to the low frequency range. However, there could be a case when the use of active noise cancellation is required at higher frequency range. Therefore, the purpose of this paper is to find out how much high-frequency noise can be controlled by applying active noise cancellation and the performance of ANC according to the equipment used. For this end, an ANC experimental environment was installed at the passenger's seat interior vehicle. By using Filtered-x Least Mean Square (FxLMS) algorithm based on adaptive control, ANC was conducted to reduce the high frequency noise in the 2kHz~4kHz and its noise reduction performance was compared according to the following variables: Filter length, step size, sampling frequency, etc. As a result of selecting the audio DSP board as the control system and applying appropriate filter length, step size, and sampling frequency, noise reduction of up to 40 dB(A) was obtained at the position of both ears of the occupant.

1. INTRODUCTION

High-frequency noise is highly sensitive to the human perception and specifically, high-frequency noise generated within vehicles can be perceived by passengers as negative impression in the viewpoint of the sound quality of the vehicle. Therefore, efforts are being made to decrease high-frequency noise to improve the passenger's environment.

There are cases where passive noise control methods are not effective at reducing higher order motor noise. The active noise control technology, which incorporates control systems to eliminate noise, is gaining attention due to its advantages in overcoming these limitations. Nevertheless, active noise control in the high-frequency range is generally challenging due to hardware performance and limitations in the spatial control area. In this study, to achieve successful active noise cancelling, the system was meticulously designed and optimized by employing high-performance hardware, strategically installing microphones and speakers, and implementing signal processing algorithms. The adaptive control-based FxLMS (Filtered-x

[1] soulshin@kookmin.ac.kr
[2] oeyaugust@vizwave.net
[3] jangwonlee@hyundai.com

Least Mean Squares) algorithm was utilized to achieve effective noise reduction in the frequency range of 2kHz to 4kHz, targeting both ears of the passengers seated in the vehicle.

Experiments were conducted to account for various factors that influence the performance of high-frequency active noise control. The appropriate filter length was selected by comparing reduction performance, and the optimal step size was derived by considering noise reduction speed, reduction amount, and stability for each frequency range. Additionally, a bandpass filter (BPF) was applied to the reference signal to further enhance the effectiveness of the active noise control.

2. ACTIVE NOISE CANCELING IN HIGH FREQUENCY BANDS

2.1. Experimental Methodology and Procedures

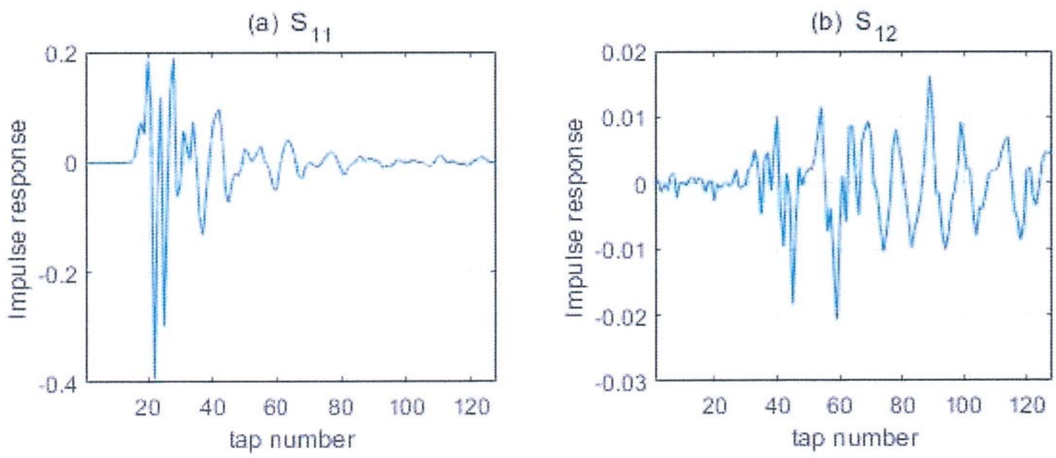
The experimental setup was installed at a stationary car environment. A function generator was utilized to generate a sine wave in the frequency range of 2kHz to 4kHz, positioned behind the driver's seat. Error microphones and control speakers were installed on the left and right sides of the passenger's headrest to measure the noise levels before and after active noise control implementation. A programmable audio DSP (Digital Signal Processing) board was employed as the controller.

2.2. Determination of Filter Length for FxLMS

The filter length for FxLMS is determined in order to model the secondary path function from the control speaker to the error microphone. This is done by simultaneously measuring the white noise signal output from the control speaker and the signal input to the error microphone. The accuracy of the secondary path functional model has a direct impact on system performance. As the filter length increases, the accuracy of the model improves, but it also increases the computational load on the DSP (Digital Signal Processor). Therefore, it is necessary to select an appropriate filter length. In DSP-based systems, the length of the filter is set to n-th power of 2 because of the efficiency of FFT operation.

Considering the limitations of the DSP specification used in this experiment, the change of the secondary path function was observed at three different filter lengths (32taps, 64taps, 128taps) and the ANC experiment was conducted. In the case of pure tone noise, there was no difference in the performance of ANC reduction according to the filter length. However, in the case of 2kHz~4kHz sweep noise, divergence occurred at 32 and 64 taps. An active noise control system needs to adapt to changes in the environment, but the filter's short length may limit its ability to adapt to changes in the environment. According to the experimental results, considering the stability and adaptability of the system, the length of the filter is selected as 128 taps in this study.

Figure 1 shows the impulse response function of the secondary path function between two control speakers and two error microphones.



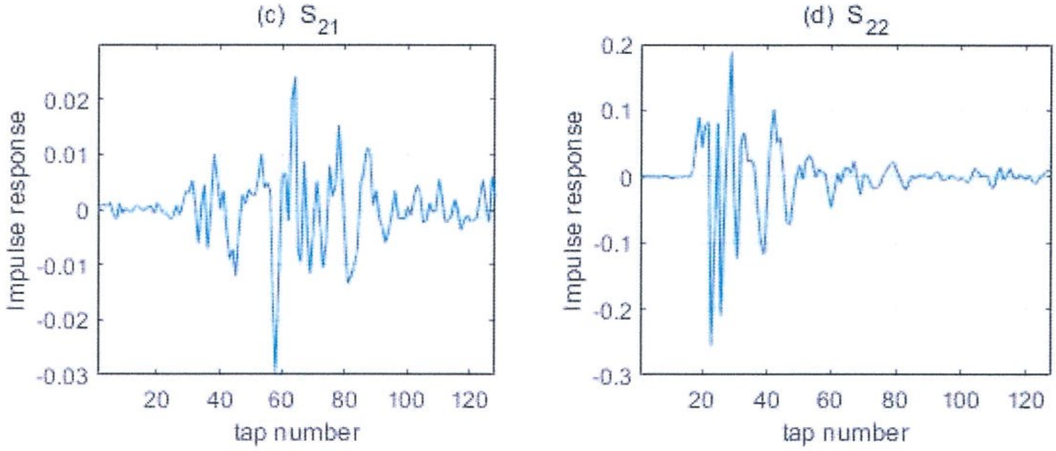


Figure 1 : Impulse response of secondary path, S_{ij} (i is an error mic., j is a control spk.)

2.3. Determination of Step-size for Adaptive Filter.
In an active noise control system, the step size plays a critical role in updating the coefficients of the adaptive filter to achieve convergence Selecting an appropriate step size is crucial for ensuring the desired response speed, system stability, performance, energy efficiency, and environmental robustness of the ANC system. However, in this study, it was observed that applying a fixed step size for active noise control in the 2kHz-4 kHz frequency range resulted in slow reduction or failure to reduce as the frequency varied. To check this issue, an experiment was conducted to determine the optimal step size for achieving fast reduction in each frequency band. The results of this experiment, considering factors such as the decay rate, decay amount, and stability for each frequency band, are presented in Table 1.

Table 1 : Empirical appropriate step sizes according to frequency range

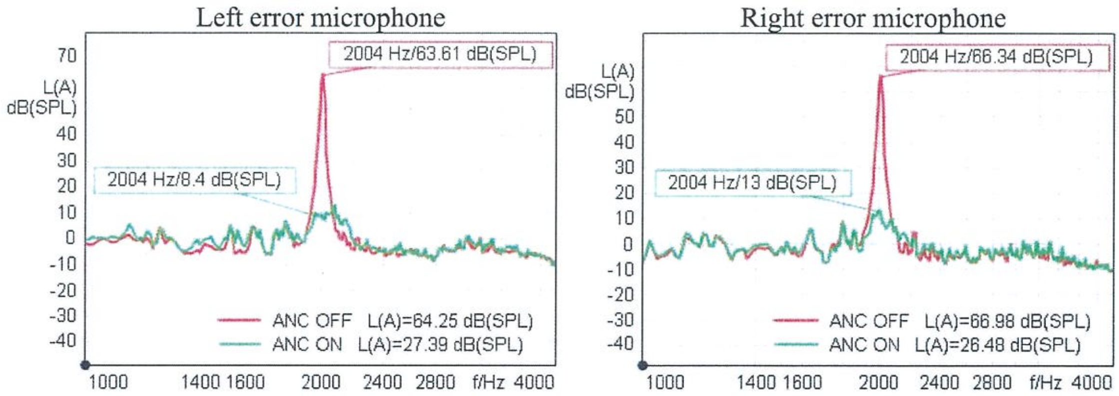
Frequency range	Step size
2 ~ 2.5 kHz	0.005
2.5 ~ 3.7 kHz	0.05
3.7 ~ 4 kHz	0.5

2.4. Application of band pass filter (BPF) for active noise control target frequency band
When acquiring the reference signal, a Band Pass Filter (2nd order Butterworth filter) with cutoff frequencies of 2kHz and 4kHz is applied to selectively pass signals within the range of 2kHz to 4kHz, which is the target frequency band for noise control. This allows for accurate acquisition of information within the desired frequency band while eliminating noise or interference from other frequency bands. By applying a BPF to the reference signal, several benefits can be achieved, including improved ANC performance due to frequency selectivity, enhanced noise rejection, system stability, and increased computational and processing efficiency.

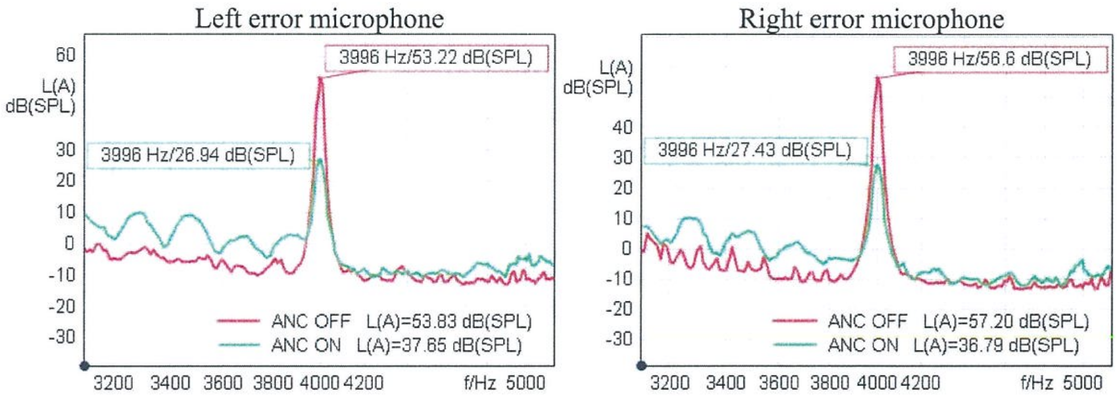
3. RESULT OF ANC

Figures 2 and 3 show the results of pure tone noise control using an active noise control system, with the same step size selected for each frequency range, but the difference before and after applying BPF. Figure 2 (a) shows the result that the overall level was decreased as many as 36.86 dB(A) at the left error mic. and 40.5 dB(A) at the right one, respectively for 2 kHz pure tone. In addition, at 4 kHz, the reduction effect of 16.18 dB(A) for the left side and 20.41 dB(A) for the right side was confirmed. In the results confirmed by applying the Band Pass Filter (BPF) as shown in Figure 3, a reduction effect of 38.37 dB(A) at the left error mic. and 41.68 dB(A) at the right error mic. was confirmed at 2 kHz. Furthermore, at 4 kHz, a reduction effect of 27.91 dB(A) at the left error mic. and 32.53 dB(A) at the right error mic. was confirmed.

Table 2 compares the ANC attenuation in Fig. 2 and Fig. 3. According to the results of Table 2, an improvement in ANC performance was observed before and after application of BPF.

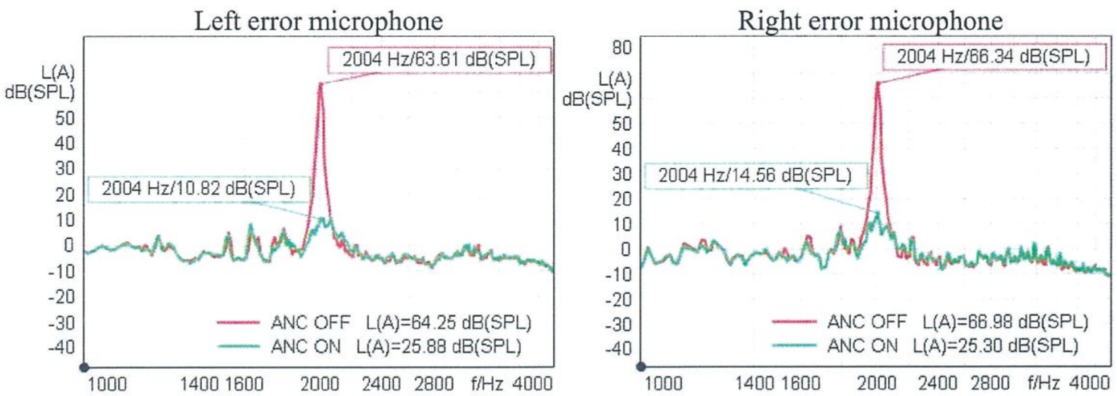


(a) 2 kHz pure tone ANC

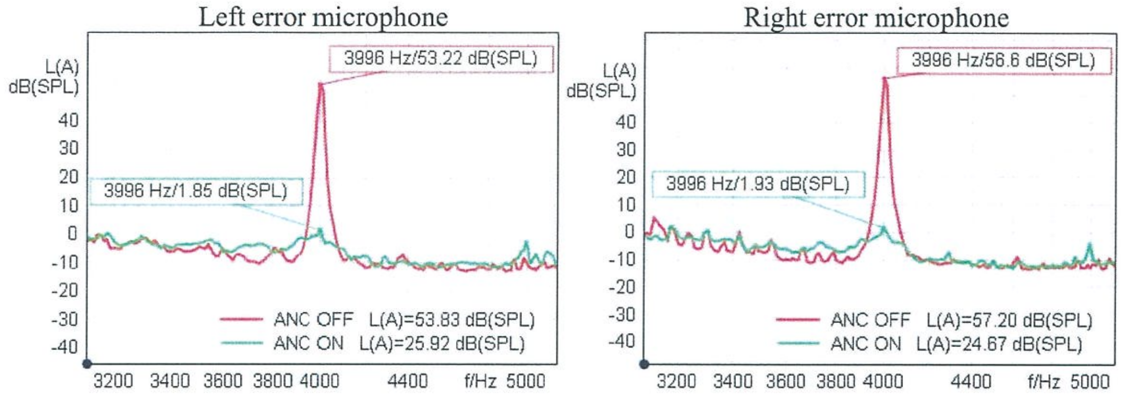


(b) 4 kHz pure tone ANC

Figure 2: Comparison of pure tone ANC control on/off results without BPF



(a) 2 kHz pure tone ANC



(b) 4 kHz pure tone ANC

Figure 3: Comparison of BPF-applied pure tone ANC control on/off results

Table 2: Attenuation according to BPF application

		W/O BPF [dBA]	W BPF [dBA]
2 kHz	Left	36.86	38.37
	Right	40.5	41.68
4 kHz	Left	16.18	27.91
	Right	20.41	32.53

4. CONCLUSION

In this study, an ANC system was proposed as a way to control high-frequency noise in the vehicle's interior environment. The DSP board was selected as the ANC control system, the FxLMS algorithm was applied, and the performance of the ANC system was confirmed by selecting an appropriate filter length and step size. An appropriate filter length was selected by measuring the quadratic path function model in the actual vehicle interior space, and the experiment was conducted using sine wave 2 kHz, 4 kHz, and 2~4 kHz sweep signals as reference signals. By selecting different step sizes for each frequency range, the attenuation speed and stability were increased, and the performance was supplemented by applying a BPF of 2 to 4 kHz to the reference signal. In general, active noise control shows effective control performance mainly at low frequencies, but in this study, the effectiveness of the algorithm and the reduction performance of about 40 dB(A) at up to 4 kHz were confirmed through control experiments. As a result of the experiment by fixing the control points of both ears, it is thought that additional research is needed to verify the control performance by expanding the narrow quiet space.

ACKNOWLEDGEMENTS

This paper was supported by Korea Institute for Advancement of Technology (KIAT) grant funded by the Korea Government (MOTIE) (P0020536, HRD Program for Industrial Innovation) and BK21 Four Program (5199990814084) of the National Research Foundation of Korea (NRF) funded by the Ministry of Education.

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4단계 BK21사업 자율주행 xEV 혁신 인재 교육연구단

국제학술대회 사전계획서

학회명	Inter-noise 2023		
개최국	일본	개최장소	도쿄
신청인	신성환	-	
논문 제목	- Factor affecting dynamic feeling of vehicle sound related to firing-order component and its effect - Active noise control performance in the high-frequency range		
참가목적	학술대회 참가, 연구실 인원 발표 참관, 학술 교류		
BK사업과의 연구 관련성	xEV의 Active Sound Design(Generating)의 방법론 연구 EV에서 발생하는 고주파 소음 제어를 위한 연구		

1. 일정 세부 계획안

NO	날짜	세부일정	활동내역
1	08.19	일본 도착 발표 대본 검토 및 리허설	출발 및 일본 도착(~18:30) 숙소 이동 저녁 식사 발표 대본 검토 및 리허설 참관(~21:00)
2	08.20	학회 참석 1일차 참석 희망 세션 논문 스터디 발표 자료 검토 및 리허설 개회식 참석 Plenary Lecture 수강	발표자료 검토 및 리허설 참관(~15:00) 학회장 이동 개회식 참석(16:00~17:00) Plenary Lecture: Sound in Life and Acoustics for Society 수강(17:00~18:00)
3	08.21	학회 참석 2일차 세션 참가 및 학술 교류 포스터 발표 참관	Keynote lecture: Underwater Acoustics and Marine System 수강(08:20~09:20) 05. Active Control of Sound &

		포스터 발표 참관	Acoustics and Marine System 수강(08:20~09:20) 05. Active Control of Sound & Vibration	Poster Session 참석(09:40~12:20) 포스터 발표 참관(한승연) 점심 식사(~13:20) Keynote lecture: Exploring Real-World Geometry Effects on Airfoil and Bluff-Body Flow Noise 수강(13:20~14:20) 07.3 Airport Noise 세션 참석(14:20~18:00)
4	08.22	학회 참석 3일차 세션 참가 및 학술 교류 논문 구두 발표	Keynote lecture: The Short Story of Urban Acoustics 수강(08:20~09:20) 15.2 세션 참석(09:40~12:00) 구두 발표 참관(류동규) 점심 식사(~13:20) 08.2 Interior Noise & Sound Design 세션 참석(14:40~15:40) 15.0 Sound Quality & Product Noise: General 세션 참석(16:00~18:20)
5	08.23	학회 참석 4일차 세션 참가 및 학술 교류 귀국	07.7 Urban Air Mobility Community Noise 세션 참가(08:40~10:00) 공항 이동(10:00~) 귀국 및 귀가(12:25~)

2. 예산계획안

일련번호	지원 항목	계산내역	지원신청액	비고
1	학회등록비	81,200 JPY = 826,292 대한민국 원	826,292 원	
2	항공비	752,900 원	752,900 원	
3	숙박비	$ 180 * 4박 = $ 720 938,966 대한민국 원	938,966 원	
4	일비	$ 50 * 5일 = $ 250 326,030 대한민국 원	326,030 원	
5	기타			
합 계			2,844,188 원	

위의 건에 대하여 사전 계획서를 제출합니다.

2023년 07월 11일

자율주행 xEV혁신인재 교육연구단장 귀하

				담 당	검 토	부단장	연구단장
신 청 인 :	신 성 환	(인)	결재				
참 여 교 수 :	신 성 환	(인)					

BrainKorea21 FOUR

Receipt

Issued Date Jul. 10, 2023
Date of Order May. 11, 2023
No. A01182

Received from Sung-Hwan Shin

The below sum has been duly received.

Method of Payment	Credit-card payment
Received Payment on	May. 11, 2023

Inter-Noise 2023
Congress President Shinichi Sakamoto

Amount	81,200 JPY

Classification / Items		Unit	Order	Amount
Inter-Noise 2023 Registration Fee	Regular Participant (up to May 29)	81,200 JPY	1	81,200 JPY
Additional Papers	No additional papers	0 JPY	1	0 JPY
Accompanying Persons	No: Unaccompanied	0 JPY	1	0 JPY
Banquet [CLOSED]	No: Not Attend	0 JPY	1	0 JPY
			Total	81,200 JPY

Received for Inter-Noise 2023 expenses.

REGISTRATION FEES

(in JPY)

<table>
<tr><th></th><th>Up to May 29</th><th>Up to July 21</th><th>After July 22</th></tr>
<tr><td>Regular participant</td><td>81,200</td><td>86,800</td><td>92,400</td></tr>
<tr><td>Student</td><td colspan="2">16,800</td><td>22,400</td></tr>
<tr><td>Accompanying person</td><td colspan="3">16,800</td></tr>
<tr><td>Additional paper</td><td colspan="3">8,400</td></tr>
</table>

※Up to May 29: Early bird, Up to July 21: Regular, After July 22: Registration can only be made at the venue

The registration fees apply whether an on-site or online delegate.

For **On-site delegates**, Registration Fee includes the following items:

– All conference materials

– Access to all scientific sessions, exhibition

– Refreshment breaks

– Access to online livestreams and recorded presentations.

For **Online delegates**, registration fee includes the following items:

– Access to 8 live streams (opening and closing ceremony, 2 plenary and 4 keynote presentations) directly from Inter-Noise 2023 from the International Conference Room.

– Access to the recordings of the presentations of the technical sessions. (recordings will be available within approximately 24 hours after the congress has taken place).

Registration Fees are in JPY and include VAT @ 10%

우리카드

국외이용 매입조회

성 명 : 국민대학교산학협력단

접 수 기 간 : 2023-05-01 ~ 2023-05-31

순번	카드번호	매출일자	매출종류	이용금액(현지)		이용금액(USD)	이용금액(원화)	해외이용수수료	청구금액
	가맹점명	매입일자	MCC	현지통화	국가	적용환율	승인번호	현금이용수수료	결제일자
1	5584-20**-****-0790	2023-05-09	일시불		16,800.00	126.10	170,802	507	171,309
	INTERNOISE2023	2023-05-15	5964	일본 엔	일본	1,354.50	646318	0	2023-06-23
2	5584-20**-****-0790	2023-05-09	일시불		16,800.00	126.10	170,802	507	171,309
	INTERNOISE2023	2023-05-15	5964	일본 엔	일본	1,354.50	646545	0	2023-06-23
3	5584-20**-****-0790	2023-05-11	일시불		81,200.00	610.98	823,845	2,447	826,292
	INTERNOISE2023	2023-05-16	5964	일본 엔	일본	1,348.40	745212	0	2023-06-23

총건수	미화환산금액 합계(USD)	원화환산금액 합계	해외이용수수료 합계	현금수수료 합계	청구금액 합계
3	863.18	1,165,449	3,461	0	1,168,910

KOREAN AIR e-티켓 확인증
e-Ticket Itinerary & Receipt

0952 / 11MAY2023

승객성명 Passenger Name	항공권번호 Ticket Number	예약번호 Booking Reference
SHIN/SUNGHWAN MR (KE11391757****)	**1802336840455**	**15545696** (6BKYQY)

여정 Itinerary

출발 From		도착 To	편명 Flight
GMP 서울(Gimpo) **19AUG2023(토) 16:15** (Local Time) Terminal No : I (Sky City International Terminal)	✈	**HND** 도쿄(Haneda) **19AUG2023(토) 18:30** (Local Time) Terminal No : 3	**KE2103** Operated by KE KOREAN AIR

예약등급 Class : M (일반석)	예약상태 Status : OK (확약)	좌석번호 Seat number : 28B
운임 Fare Basis : MLE0ZRKA	수하물 Baggage : **1 Piece**	항공권 유효기간 Validity : -19AUG2024
기종 Aircraft Type : Airbus A330-300	비행시간 Flight Duration : 02H 15M	SKYPASS 마일리지 SKYPASS Miles : 758

출발 From		도착 To	편명 Flight
HND 도쿄(Haneda) **23AUG2023(수) 12:25** (Local Time) Terminal No : 3	✈	**GMP** 서울(Gimpo) **23AUG2023(수) 14:45** (Local Time) Terminal No : I (Sky City International Terminal)	**KE2102** Operated by KE KOREAN AIR

예약등급 Class : M (일반석)	예약상태 Status : OK (확약)	좌석번호 Seat number : 28B
운임 Fare Basis : MLE0ZRKA	수하물 Baggage : **1 Piece**	항공권 유효기간 Validity : -19AUG2024
기종 Aircraft Type : Airbus A330-300	비행시간 Flight Duration : 02H 20M	SKYPASS 마일리지 SKYPASS Miles : 758

- 스케줄, 기종 및 좌석등급(서비스클래스)는 부득이한 사유로 사전 예고없이 변경될 수 있습니다. 또한 항공기 교체등의 부득이한 사유로 선택하신 좌석이 변경될 수 있으니 탑승수속 시 기종 및 좌석번호를 재확인해 주시기 바랍니다.

여정 1 GMP → HND

2023년 08월 19일 (토)

16:15 서울/김포 · 터미널 I **GMP**	총 2시간 15분 소요	**18:30** 도쿄/하네다 · 터미널 3 **HND**

체크인

KE2103 A330-300 일반석(M)

SHIN SUNGHWAN

신청된 서비스 확인/변경 및 다른 부가서비스 신청

28B | 입력 전 | 더보기

여정 2 HND → GMP

2023년 08월 23일 (수)

12:25 도쿄/하네다 · 터미널 3 **HND**	총 2시간 20분 소요	**14:45** 서울/김포 · 터미널 I **GMP**

체크인

KE2102 A330-300 일반석(M)

SHIN SUNGHWAN

신청된 서비스 확인/변경 및 다른 부가서비스 신청

28B | 입력 전 | 더보기

영수증

인쇄하기

KOREAN AIR

카드종류 / Card Type CA	거래유형 / Form of Payment Credit Card
카드번호 / Card No. ************0790	
유효기간 / Expiry Date **/**	거래일자 / Approval Date 11MAY2023
항공권번호 / Ticket No. 1802336840455	
승객 / Passenger SHIN/SUNGHWAN MR	
지불운임 / Fare KRW 630,000	여정 / Itinerary GMP-HND-GMP
Taxes and Fuel SurCharge 세금 / Taxes KRW 66,900 유류할증료 / Fuel SurCharge KRW 56,000	예약번호 / Booking Reference 15545696 할부기간 / Installment 일시불 승인번호 / Approval No. 48439898 가맹점명 / Merchant Name (주)대한항공(Korean Air)
결제금액 / Payment Amount KRW 752,900	대표자 / President 우기홍 외 1명
가맹점 주소 / 서울특별시 강서구 하늘길 260 (공항동) Address / 260, Haneul-gil, Gangseo-gu, Seoul, Korea	
사업자등록번호 / Business Registration No. 110-81-14794	

August 20 (Sun)

No.	Venue	16:00–17:00	17:00–18:00
1	Int'l Conf Rm (2F)	Opening	Plenary 1
9	Rm 201A	Live Streaming	Live Streaming
10	Rm 201B	Live Streaming	Live Streaming

August 21 (Mon)

No.	Venue	Morning	Morning (after Break)		Afternoon	Afternoon (after Break)
1	Int'l Conf Rm (2F)	Keynote 1; 18.1	18.1	Lunch	Keynote 2; 18.1	18.1
2	Rm 101A	02.1	02.1	Lunch	02.2	02.0
3	Rm 101B	11.5	11.5	Lunch	11.5	15.3
4	Rm 102A	09.1	09.0	Lunch	09.0	05.1
5	Rm 102B	03.4	03.4	Lunch	03.2	03.2
6	Rm 103	01.0	01.0	Lunch	01.0	01.0
7	Rm 104	03.0	03.0	Lunch	03.0	03.0
8	Rm 105	04.0	04.0	Lunch	04.1	04.1
9	Rm 201A	06.3	06.4	Lunch	06.4	06.1
10	Rm 201B	13.3	13.3	Lunch	07.3	07.3
11	Rm 202	12.0	12.1	Lunch	12.1	13.1
12	Rm 301A	08.3	08.1	Lunch	08.1	08.1
13	Rm 301B	11.0	11.0	Lunch	11.1	11.1
14	Rm 302	12.8	12.8	Lunch	12.5	12.5
15	Rm 303	14.0	14.1	Lunch	14.2	14.1
16	Rm 304	16.0	16.1	Lunch	16.1	16.3
P	Lobby (2F)	Poster:01-05		Lunch	Poster:06-10	

August 22 (Tue)

No.	Venue	Morning	Morning (after Break)		Afternoon	Afternoon (after Break)
1	Int'l Conf Rm (2F)	Keynote 3		Lunch	Keynote 4; Banquet Preparation	Banquet Preparation
2	Rm 101A	02.2	02.3	Lunch	02.0	01.2
3	Rm 101B	05.0	05.0	Lunch	05.3	05.3
4	Rm 102A	13.4	13.4	Lunch	10.1	10.1
5	Rm 102B	06.5	06.5	Lunch	07.2	07.2
6	Rm 103	01.1	01.1	Lunch	01.1	01.1
7	Rm 104	03.2	03.1	Lunch	03.1	03.1
8	Rm 105	04.4	04.1	Lunch	04.2	04.2
9	Rm 201A	06.2	06.2	Lunch	06.2	06.6
10	Rm 201B	07.4	07.4	Lunch	07.5	07.5
11	Rm 202	15.2	15.2	Lunch	08.2	15.0
12	Rm 301A	13.2	13.2	Lunch	08.0	08.0
13	Rm 301B	12.6	12.6	Lunch	11.1	11.1
14	Rm 302	12.9	12.9; 12.2	Lunch	12.2	12.2
15	Rm 303	14.5	14.3	Lunch	14.3	14.3
16	Rm 304	16.2	16.2	Lunch	13.0	13.0
P	Lobby (2F)	Poster:11-12		Lunch	Poster:13-17	

August 23 (Wed)

No.	Venue	Morning	Morning (after Break)		Afternoon	After Break
1	Int'l Conf Rm (2F)		18.2	Lunch	18.2	Plenary 2; Closing
2	Rm 101A	12.4	12.3	Lunch	12.3	
3	Rm 101B	05.2	05.2	Lunch	05.2	
4	Rm 102A	10.2	10.2; 10.3	Lunch	10.3	
5	Rm 102B	07.1	07.1	Lunch	07.6	
6	Rm 103	01.2	01.3	Lunch	01.3	
7	Rm 104	03.3	03.3	Lunch	03.3	
8	Rm 105	04.3	04.3; 04.5	Lunch	04.5	
9	Rm 201A	06.3	06.3	Lunch	15.1	
10	Rm 201B	07.7	07.7	Lunch	11.3	
11	Rm 202	17.0	15.4	Lunch	17.0	
12	Rm 301A	08.2	08.0	Lunch	08.0	
13	Rm 301B	11.4	11.2	Lunch	11.2	
14	Rm 302	12.9	12.7	Lunch	12.7	
15	Rm 303	14.4	14.6	Lunch	14.6	
16	Rm 304	16.5	14.5	Lunch	16.4	

Areas	Sessions
01. Flow-induced Noise & Vibration	01.0 Flow-induced Noise & Vibration: General
	01.1 Computational Methods in Flow-induced Noise & Vibration
	01.2 Experiments in Flow-induced Noise & Vibration
	01.3 Rotor & Turbomachinery Noise
02. Vibro-acoustics	02.0 Vibro-acoustics: General
	02.1 Numerical Methods in Vibro-acoustics
	02.2 Vibro-acoustics Experiments
	02.3 Application of Vibro-acoustics Methods to Noise Control
03. Signal Processing & Measurements	03.0 Signal Processing & Measurements: General
	03.1 Microphone Array Techniques
	03.2 Spatial Capture & Reproduction
	03.3 Measurement Instrumentation
	03.4 Measurement Standard
04. Modeling & Numerical Simulation	04.0 Modeling & Numerical Simulation: General
	04.1 Room Acoustics Modeling & Simulation
	04.2 Vibration Analysis
	04.3 Numerical Techniques in Acoustics & Vibration
	04.4 Sound Source Modeling
	04.5 Sound Propagation Modeling & Simulation
05. Active Control of Sound & Vibration	05.0 Active Control of Sound & Vibration: General
	05.1 Active & Passive Noise Control
	05.2 Signal Processing & Algorithms for ANC
	05.3 New Applications of Active Control
06. Transportation Noise & Vibration	06.1 Railway Vehicle Acoustics
	06.2 Railway Noise
	06.3 Tire & Road Noise
	06.4 Noise Barriers & Mitigation Techniques
	06.5 Road Traffic Noise Calculation Methods
	06.6 Road Vibrations: Predictions, Measurements & Mitigation Measures
07. Aircraft Noise	07.1 Aircraft Interior Noise
	07.2 Aircraft Exterior Noise
	07.3 Airport Noise
	07.4 Airport Noise Modeling & Mapping
	07.5 Advanced Monitoring & Measurement
	07.6 Supersonic Aircraft Noise
	07.7 Urban Air Mobility Community Noise
08. Vehicle Noise & Vibration	08.0 Vehicle Noise & Vibration: General
	08.1 Pass-by Noise, Tire & Pavement
	08.2 Interior Noise & Sound Design
	08.3 Noise & Vibration of Electric, Hybrid & Alternative Powertrains
09. Industrial Noise	09.0 Industrial Noise: General
	09.1 Wind Turbine Noise
10. Underwater & Maritime Acoustics	10.1 Target Detection & Classification
	10.2 Measurement & Control of Ship Noise
	10.3 Effect of Noise on Aquatic Animals & Noise Exposure Criteria
11. Acoustic Materials	11.0 Acoustic Materials: General
	11.1 Acoustic Metamaterials
	11.2 Microperforated Materials
	11.3 Sound Absorbers & Diffusers
	11.4 Additive Manufacturing for Acoustic Applications
	11.5 Sound Absorption Measurements

Areas	Sessions
12. Building & Architectural Acoustics	12.0 Building & Architectural Acoustics: General
	12.1 Requirements, Classification Schemes & Standards in Building Acoustics
	12.2 Impact & Structure-borne Sound in Buildings
	12.3 Ventilation-enabling Sound Insulation Devices
	12.4 Building System Noise & Vibration Control
	12.5 Sound Insulation Measurement & Prediction
	12.6 Sound Insulation of Wooden Buildings
	12.7 Acoustics of Education Spaces
	12.8 Acoustics of Workspaces
	12.9 Acoustics in Indoor Spaces
13. Environmental Noise	13.0 Environmental Noise: General
	13.1 Noise Mapping
	13.2 Smart Cities & Noise Monitoring
	13.3 Outdoor Noise Propagation
	13.4 Low-frequency Sound
14. Perception & Health	14.0 Perception & Health: General
	14.1 Community Response to Noise
	14.2 Noise & Health
	14.3 Psychoacoustics of Noise Evaluation & Universal Design
	14.4 Physiological & Emotional Responses to Environment Sound
	14.5 Occupational Noise & Hearing Loss
	14.6 Response to Noise & Vibration
15. Sound Quality & Product Noise	15.0 Sound Quality & Product Noise: General
	15.1 Psychological & Physiological Evaluation of Product Noise
	15.2 Product Sound Quality
	15.3 Information Technology Equipment Noise
	15.4 Sound Design Based on Psychoacoustics
16. Soundscapes	16.0 Soundscapes: General
	16.1 Soundscape Evaluations: Towards the Development of Standards
	16.2 Outdoor Soundscape Planning & Design, and Urban Design
	16.3 Indoor Soundscape Planning & Design
	16.4 Soundscape Preservation
	16.5 Artificial Intelligence & Machine Learning on Soundscape
17. Noise Policy & Management	17.0 Noise Policy & Management: General
18. Theme-related & Novel Approaches	18.1 Inclusive Design of Sound Environment
	18.2 Diversity of Local Noise Issues in the World