

MEASUREMENT RESULTS REPORT

1. Submission

The following measurement results are submitted as a report on the joint use of research equipment for technical support to small and medium-sized enterprises.

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2. Equipment Under Test

- Equipment name: MUTI Chip ver. 2.1 module
- Model and serial number: MUTI-B / SN:001
- Manufacturer: MUTi Inc.

Photographs of the actual equipment under test are shown in Figures 1 and 2 below.



Figure 1. Bottom view of the equipment under test.

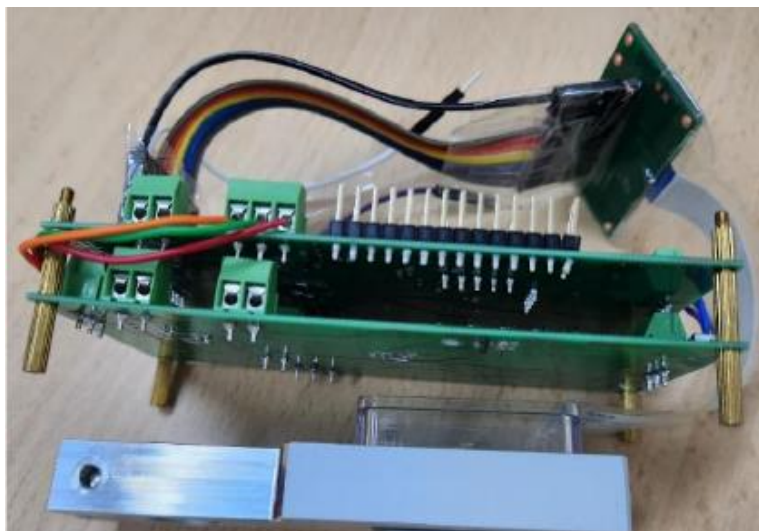
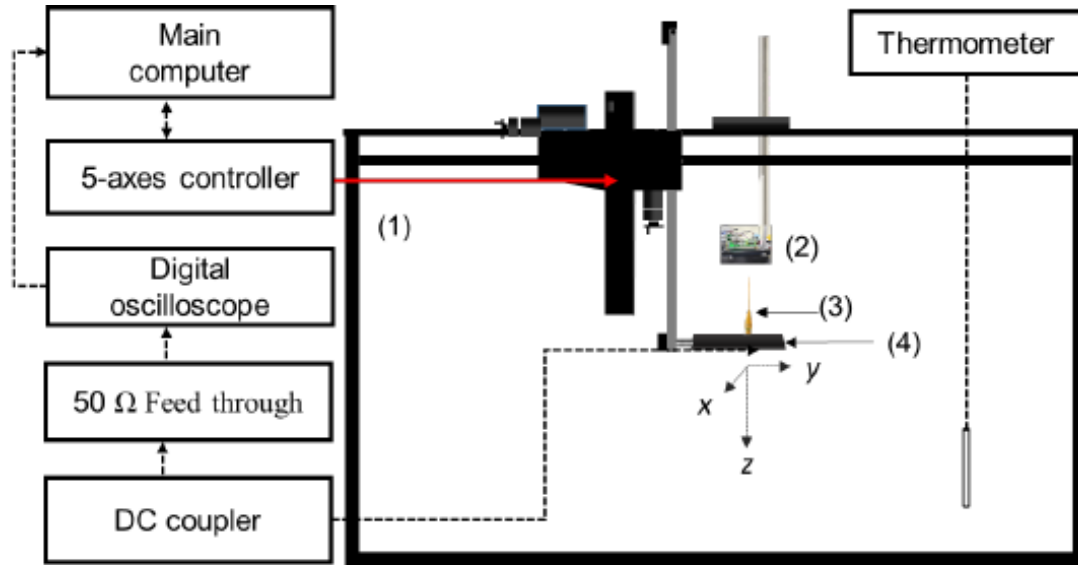


Figure 2. Side view of the equipment under test.

Measurement System Configuration

The measurement system configuration is shown in Figure 3.



(1) Water, (2) DUT, model: Muti-Chip ver. 2.1 module /SN: 001, (주)무티, (3) Hydrophone, model: NH-0250 SN: 098, Precision Acoustics Co. (4) Hydrophone mount

Figure 3. Measurement system configuration: (1) degassed triple-distilled water, (2) equipment under test, model: MUTI-Chip ver. 2.1 module, serial no.: 001, (3) hydrophone used for measurement, model: NH0025, SN:098, and (4) hydrophone mount.

3. Notes for Presentation of the Measurement Results

- Voltage square integral

$$V_{II}(t) = \int_{t_0}^t V(t') dt'$$

- Pulse width

$$pw = 1.25(\tau_{90} - \tau_{10})$$

- τ_{90} : time at which $V_{II}(t)$ reaches 90% of the maximum value of $V_{II}(t)$
- τ_{10} : time at which $V_{II}(t)$ reaches 10% of the maximum value of $V_{II}(t)$
- Coordinate correction equation for the z-axis (acoustic radiation axis)

$$z_{cor} = z_m - (z_{tf-ref} - \sqrt{(z_{tf-ref}^2 - r_{ch8}^2)})$$

- z_m : coordinate provided by the equipment
- z_{tf-ref} : coordinate based on flight time (coordinate of one find-pulse point)
- r_{ch8} : lateral distance to Channel 8, which provided the trigger signal (customer-provided value: 5 mm)

4. Measurement Results - 4-1. Transducer System Setting 1 (Nominal Focus: 6 mm) (February 3, 2023)

4. 측정결과

4-1. 변환기 시스템 설정 1 (공칭초점 6 mm)의 측정 결과. (2/3/2023)

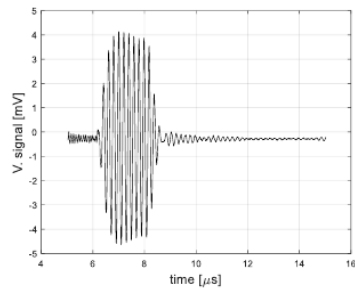


그림 4. 수중 청음기 수신 신호.

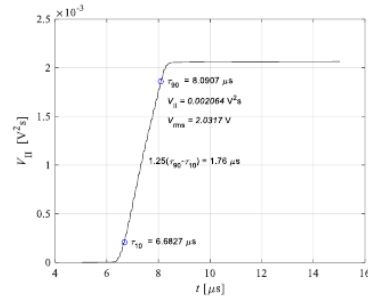


그림 5. V-제곱 적분 및 펄스 폭.

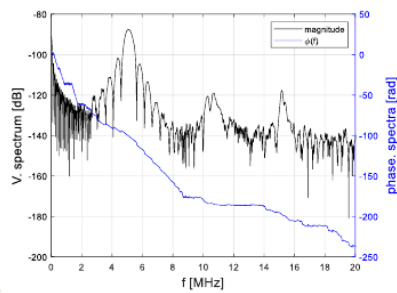


그림 6 수중 청음기 수신 신호의 스펙트럼.

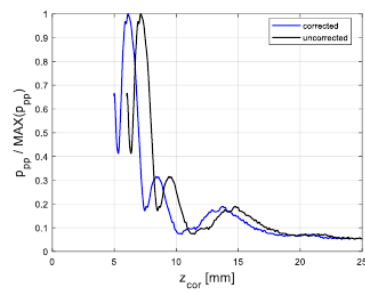


그림 7. 음향 방사 축상 주사 결과.

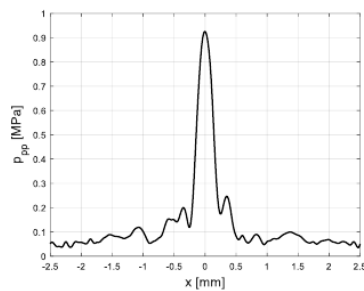


그림 8. x-축상 주사 결과.

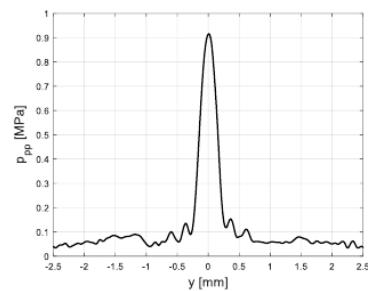


그림 9. y-축상 주사 결과.

Table 1. Data for each measurement parameter under Condition 1.

표 1. 조건 1의 측정 파라미터 별 데이터.

Waveform results	Measurement	Std. uncertainty
Z Distance [mm]	7.29	0.03
Z_cor Distance [mm]	5.96	0.03
Temperature [°C]	28.06	0.01
Peak Positive Pressure [MPa]	0.481	0.004
Peak Negative Pressure [MPa]	0.472	0.003
Peak-to-Peak Pressure [MPa]	0.953	0.007
Peak Positive Pressure (derated) [MPa]	0.423	0.004
Peak Negative Pressure (derated) [MPa]	0.415	0.003
Peak-to-Peak Pressure (derated) [MPa]	0.838	0.006
Pulse Average Intensity [W/cm ²]	6.18	0.24
Temporal Average Intensity [mW/cm ²]	21.70	0.85
Pulse Average Intensity (derated) [W/cm ²]	4.78	0.18
Temporal Average Intensity (derated) [mW/cm ²]	16.79	0.63
Pulse duration [us]	1.76	0.00
Center Frequency [MHz]	5.09	0.00
-3dB Bandwidth [MHz]	0.470	0.007
-3dB Bandwidth percent [%]	9.23	0.14
Mechanical Index	0.18	0.00
x-scan results	Measurement	Std. uncertainty
Beam Width (mm)	0.341	0.009
Center (mm)	0.006	0.003
y-scan results	Measurement	Std. uncertainty
Beam Width (mm)	0.322	0.004
Center (mm)	0.000	0.001
z-scan results	Measurement	Std. uncertainty
Focal depth (mm)	1.55	0.03
Focal length (mm)	5.96	0.03

4-2. Transducer System Setting 2 (Nominal Focus: 8 mm) (February 3, 2023)

4-2. 변환기 시스템 설정 2 (공칭초점 8 mm)의 측정 데이터 (2/3/2023)

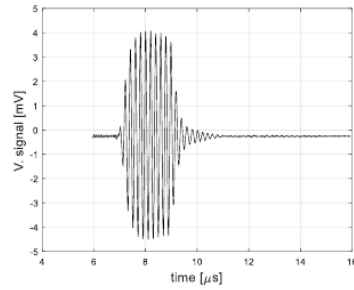


그림 8. 수중 청음기 수신 신호.

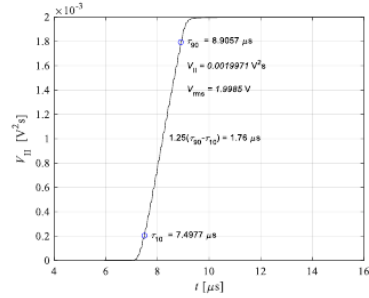


그림 9. V-제곱 적분 및 펄스 폭.

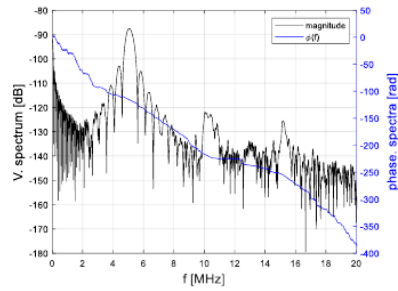


그림 10. 수중 청음기 수신 신호의 스펙트럼.

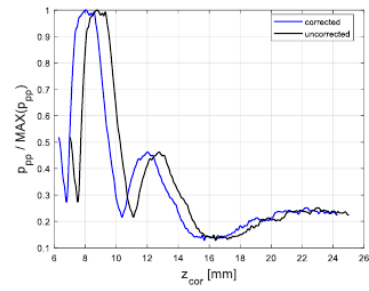


그림 11. 음향 방사 측상 주사 결과.

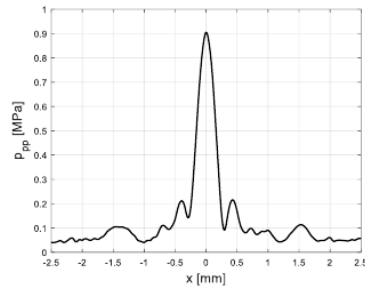


그림 12. x-축상 주사 결과.

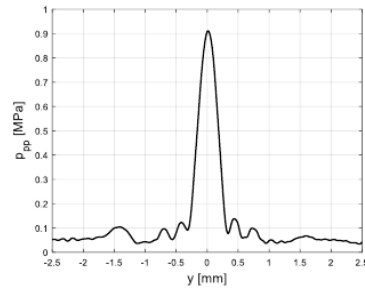


그림 13. y-축상 주사 결과.

Table 2. Data for each measurement parameter under Condition 2.

표 2. 조건 2의 측정 파라미터 별 데이터.

Waveform results	Measurement	Std. uncertainty
Z Distance [mm]	8.44	0.24
Z_cor Distance [mm]	8.03	0.04
Temperature [°C]	25.52	1.64
Peak Positive Pressure [MPa]	0.36	0.05
Peak Negative Pressure [MPa]	0.36	0.05
Peak-to-Peak Pressure [MPa]	0.72	0.10
Peak Positive Pressure (derated) [MPa]	0.31	0.04
Peak Negative Pressure (derated) [MPa]	0.31	0.04
Peak-to-Peak Pressure (derated) [MPa]	0.62	0.08
Pulse Average Intensity [W/cm ²]	4.14	1.38
Temporal Average Intensity [mW/cm ²]	14.73	4.83
Pulse Average Intensity (derated) [W/cm ²]	3.07	0.99
Temporal Average Intensity (derated) [mW/cm ²]	10.92	3.48
Pulse duration [us]	1.78	0.01
Center Frequency [MHz]	5.06	0.01
-3dB Bandwidth [MHz]	0.41	0.02
-3dB Bandwidth percent [%]	8.10	0.41
Mechanical Index	0.14	0.02
x-scan results	Measurement	Std. uncertainty
Beam Width (mm)	0.36	0.02
Center (mm)	0.006	0.006
y-scan results	Measurement	Std. uncertainty
Beam Width (mm)	0.381	0.004
Center (mm)	0.003	0.01
z-scan results	Measurement	Std. uncertainty
Focal depth (mm)	2.29	0.09
Focal length (mm)	8.03	0.04

4-3. Transducer System Setting 3 (Nominal Focus: 10 mm) (February 3, 2023)

4-3. 변환기 시스템 설정 3 (공칭초점 10 mm)의 측정 데이터 (2/3/2023)

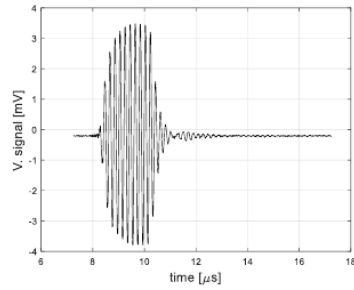


그림 14. 수중 청음기 수신 신호.

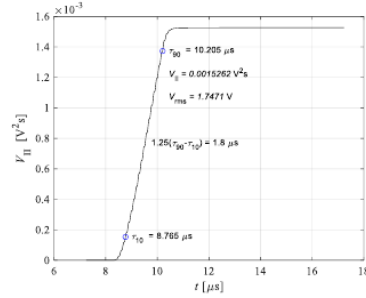


그림 15. V-제곱 적분 및 펄스 폭.

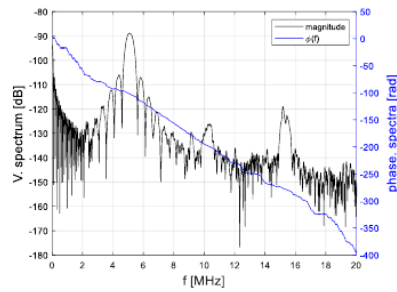


그림 16. 수중 청음기 수신 신호의 스펙트럼.

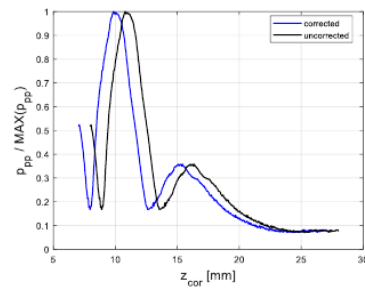


그림 17. 음향 방사 측상 주사 결과.

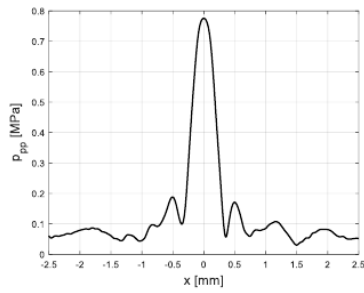


그림 18. x-축상 주사 결과.

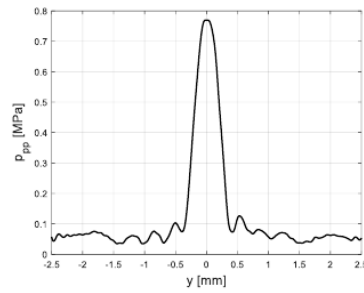


그림 19. y-축상 주사 결과.

Table 3. Data for each measurement parameter under Condition 3.

표 3. 조건 3의 측정 파라미터 별 데이터.

Waveform results	Measurement	Std. uncertainty
Z Distance [mm]	11.35	0.30
Z_cor Distance [mm]	10.25	0.09
Temperature [°C]	27.94	0.05
Peak Positive Pressure [MPa]	0.36	0.02
Peak Negative Pressure [MPa]	0.35	0.02
Peak-to-Peak Pressure [MPa]	0.72	0.03
Peak Positive Pressure (derated) [MPa]	0.30	0.01
Peak Negative Pressure (derated) [MPa]	0.29	0.01
Peak-to-Peak Pressure (derated) [MPa]	0.59	0.03
Pulse Average Intensity [W/cm ²]	3.96	0.59
Temporal Average Intensity [mW/cm ²]	14.32	2.10
Pulse Average Intensity (derated) [W/cm ²]	2.66	0.43
Temporal Average Intensity (derated) [mW/cm ²]	9.62	1.53
Pulse duration [us]	1.81	0.00
Center Frequency [MHz]	5.10	0.00
-3dB Bandwidth [MHz]	0.44	0.00
-3dB Bandwidth percent [%]	8.65	0.04
Mechanical Index	0.13	0.01
x-scan results	Measurement	Std. uncertainty
Beam Width (mm)	0.51	0.04
Center (mm)	0.006	0.003
y-scan results	Measurement	Std. uncertainty
Beam Width (mm)	0.55	0.05
Center (mm)	-0.004	0.007
z-scan results	Measurement	Std. uncertainty
Focal depth (mm)	3.94	0.59
Focal length (mm)	10.25	0.09

4-4. Transducer System Setting 4 (Nominal Focus: 12 mm) (October 7, 2021)

4-4. 변환기 시스템 설정 4 (공칭초점 12 mm)의 측정 데이터 (10/7/2021)

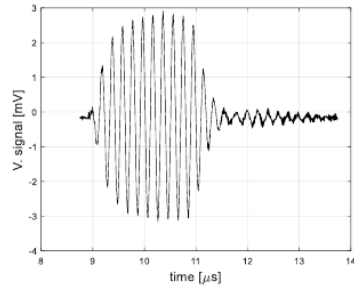


그림 20. 수중 청음기 수신 신호.

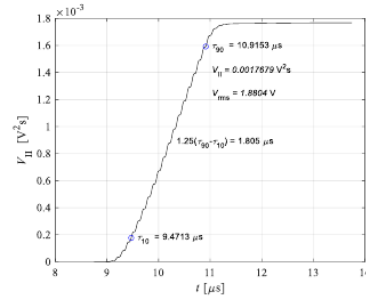


그림 21. V-제곱 적분 및 펄스 폭.

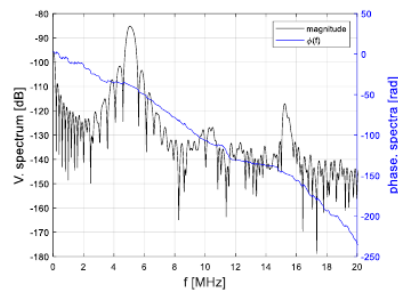


그림 22. 수중 청음기 수신 신호의 스펙트럼.

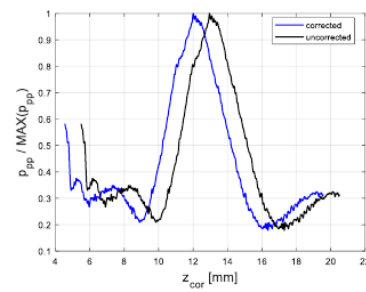


그림 23. 음향 방사 측정 주사 결과.

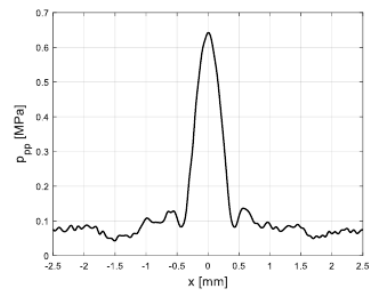


그림 24. x-축상 주사 결과.

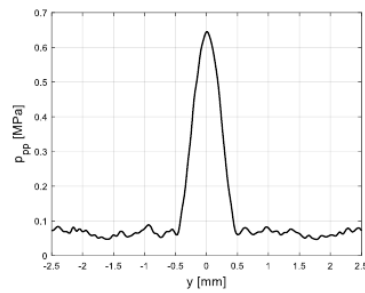


그림 25. y-축상 주사 결과.

Table 4. Original KRISS measurement table for the 12 mm setting. Note: single measurement; uncertainty was not estimated.

표 4. 조건 3의 측정 파라미터 별 데이터.

Waveform results	Measurement	Std. uncertainty
Z Distance [mm]	12.93	NA
Z_cor Distance [mm]	11.99	NA
Temperature [°C]	24.22	NA
Peak Positive Pressure [MPa]	0.33	NA
Peak Negative Pressure [MPa]	0.32	NA
Peak-to-Peak Pressure [MPa]	0.65	NA
Peak Positive Pressure (derated) [MPa]	0.26	NA
Peak Negative Pressure (derated) [MPa]	0.25	NA
Peak-to-Peak Pressure (derated) [MPa]	0.51	NA
Pulse Average Intensity [W/cm ²]	2.96	NA
Temporal Average Intensity [mW/cm ²]	10.68	NA
Pulse Average Intensity (derated) [W/cm ²]	1.88	NA
Temporal Average Intensity (derated) [mW/cm ²]	6.78	NA
Pulse duration [us]	1.80	NA
Center Frequency [MHz]	5.09	NA
-3dB Bandwidth [MHz]	0.42	NA
-3dB Bandwidth percent [%]	8.29	NA
Mechanical Index	0.11	NA
x-scan results	Measurement	Std. uncertainty
Beam Width (mm)	0.50	NA
Center (mm)	0.003	NA
y-scan results	Measurement	Std. uncertainty
Beam Width (mm)	0.55	NA
Center (mm)	0.008	NA
z-scan results	Measurement	Std. uncertainty
Focal depth (mm)	4.05	NA
Focal length (mm)	11.99	NA

주) 상기 3-4의 결과는 단 1 회의 측정으로 측정불확도 산정 불가함.