# Environmental Testing Laboratory, Inc.

11034 Indian Trail
Dallas, TX 75229-3513
(972) 247-9657
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info@etldallas.com


## CERTIFICATE OF TEST 16602A

| | |
|---|---|
| **Customer:** Radio Amateur Satellite Corporation<br>712 H Street, Suite 1653<br>Washington, DC 20002 | **Test:** Mechanical Shock |
| | **Test Completion Date:** 09 June 2022 |
| | **Purchase Order Number:** 100001 |

## Test Unit Description

One (1) Reaction Wheel Prototype

## Specification

NASA GSFC-STD-7000B dated 4-28-2021, Section 2.4.4, Mechanical Shock Qualification.

## Equipment

| Equipment Name | Description | Model # | Calibration Due |
|---|---|---|---|
| ETL #106 | ETS Solutions I1045A Vibration System | HVA3415/I1045A/GT1200M | CNR |
| ETL #111 | Unholtz-Dickie Vibration System | 12000.44 | CNR |
| ETL #1401 | Vibration Research Controller | VR9500 Revolution | 01 October 2022 |
| ETL #1534 | PCB Piezotronics Accelerometer | 352A21 | 14 March 2023 |
| ETL #1535 | PCB Piezotronics Accelerometer | 352A21 | 13 March 2023 |
| ETL #1717 | PCB Piezotronics Accelerometer | 352A21 | 04 November 2022 |
| Digital Camera | Canon Digital Camera | PowerShot D10 | CNR |

## Procedure

The test unit was mounted to the vibration table. The test unit was subjected to Mechanical Shock testing in accordance with the specification.

## Results

Radio Amateur Satellite Corporation personnel present to witness testing. Radio Amateur Satellite Corporation personnel present to witness testing. The test unit was subjected to Mechanical Shock testing in accordance with the specification. A visual examination of the test unit was performed following testing and no external damage was observed. The test results are to be determined by Radio Amateur Satellite Corporation personnel. The test unit was returned to Radio Amateur Satellite Corporation for further evaluation. Test completed 09 June 2022.

## Traceability

This Certificate of Test certifies that the above test was run in accordance with applicable specifications and that all instrumentation was in calibration and is traceable to the NATIONAL INSTITUTE OF STANDARDS and TECHNOLOGY or other recognized calibration sources when applicable.

## Accreditation

This test is accredited and meets the requirements of NASA GSFC-STD-7000B dated 4-28-2021, Section 2.4.4, Mechanical Shock Qualification. as verified by ANSI National Accreditation Board (ANAB) to ISO/IEC 17025:2017. Refer to Certificate of Accreditation and Scope of Accreditation Certificate Number: AT-1787. This document cannot be reproduced without the approval of the Laboratory.

Respectfully,
ENVIRONMENTAL TESTING LABORATORY, INC.

2022-12238
BKR/ckr

Brady Richard
President

**Environmental Testing Laboratory, Inc.**

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| | |
|---|---|
| **JOB #:** 16602A | **CUSTOMER:** Radio Amateur Satellite Corporation |
| **TEST:** Mechanical Shock | |
| **TEST UNIT:** One (1) Reaction Wheel Prototype | |
| **SPECIFICATION:** NASA GSFC-STD-7000B dated 4-28-2021, Section 2.4.4, Mechanical Shock Qualification. | |

| **EQUIPMENT LIST** | | |
|---|---|---|
| 1. Digital Camera | 6. ETL #1535 | 11. |
| 2. ETL #106 | 7. ETL #1717 | 12. |
| 3. ETL #111 | 8. | 13. |
| 4. ETL #1401 | 9. | 14. |
| 5. ETL #1534 | 10. | 15. |

| DATE | TIME | LOG AND OBSERVATIONS |
|---|---|---|
| 06/09/22 | | Checked calibration dates. |
| | | A visual examination of the test unit was performed before testing. No damage was observed. |
| | | The test unit was non-operational. |
| | | Radio Amateur Satellite Corporation representative was present to witness test. |
| | 09:29 | Start Z Axis SRS Shock per supplied profile. |
| | 09:37 | Start X Axis SRS Shock per supplied profile. |
| | 09:48 | Start Y Axis SRS Shock per supplied profile. |
| 06/09/22 | 09:48 | Test completed. |
| | | A visual examination of the test unit was performed after testing. |
| | | No damage was observed. |
| | | The test unit was returned to Radio Amateur Satellite Corporation. |
| **Technician** | | Charles Hoppe. |

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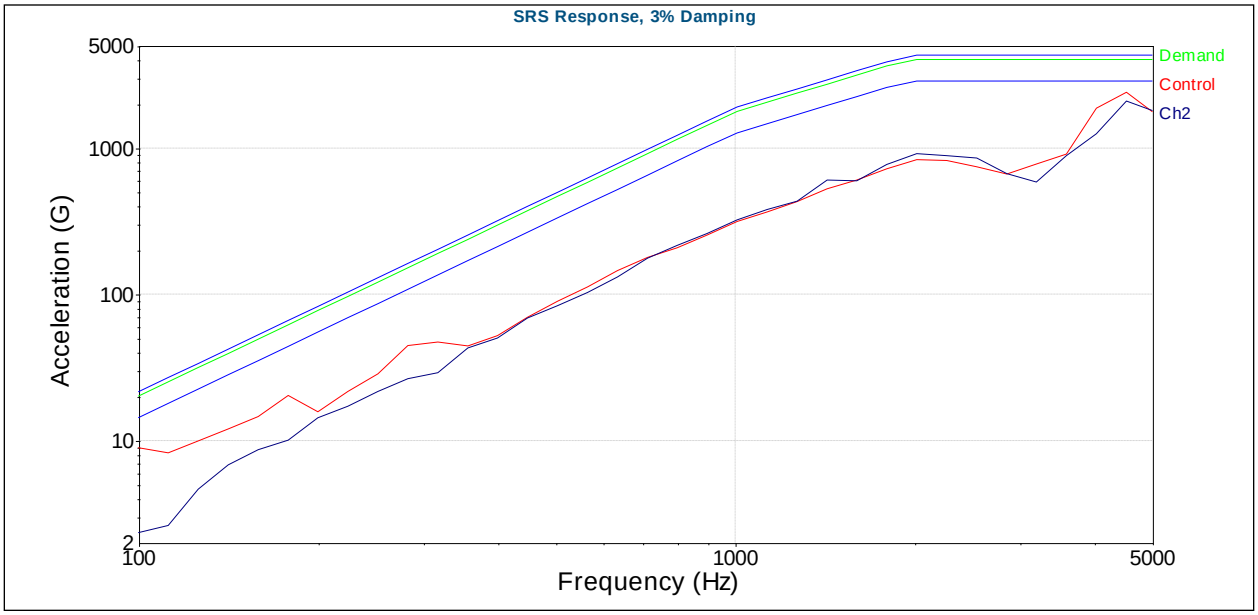
Customer: Radio Amateur Satellite.
Job#: 16602A, SRS Pulse, Z Axis.

***End of Test***




*Test level schedule:*

| | Pulses | Level |
|---|---|---|
| 1) | 2 | * 100 % |

** Test started Jun 09, 2022 09:29:16
** Current level: 1, running at 100 % for 1 of 1 pulses

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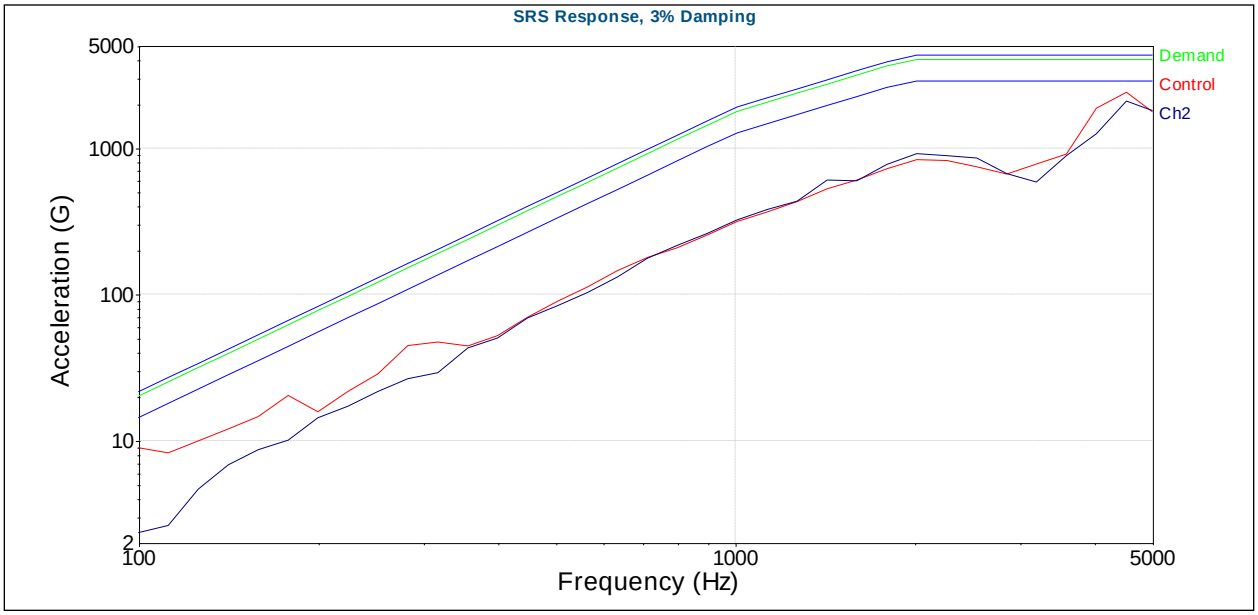
Customer: Radio Amateur Satellite.
Job#: 16602A, SRS Pulse, X Axis.

***End of Test***




*Test level schedule:*

| | Pulses | Level |
|---|---|---|
| 1) | 2 | * 100 % |

** Test started Jun 09, 2022 09:37:16
** Current level: 1, running at 100 % for 1 of 1 pulses

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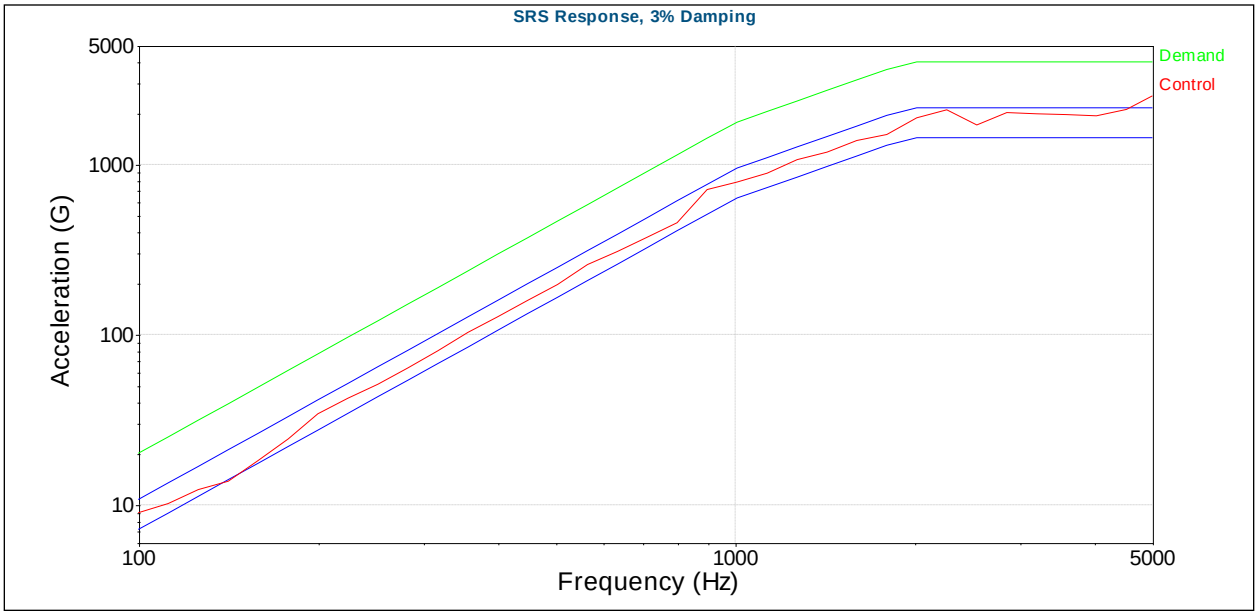
Customer: Radio Amateur Satellite.
Job#: 16602A, SRS Pulse, Y Axis.

***End of Test***




*Test level schedule:*

| | Pulses | Level |
|---|---|---|
| 1) | 1 | * 100 % |

** Test started Jun 09, 2022 09:48:11
** Current level: 1, running at 100 % for 1 of 1 pulses

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**Figure 1 - Mechanical Shock**

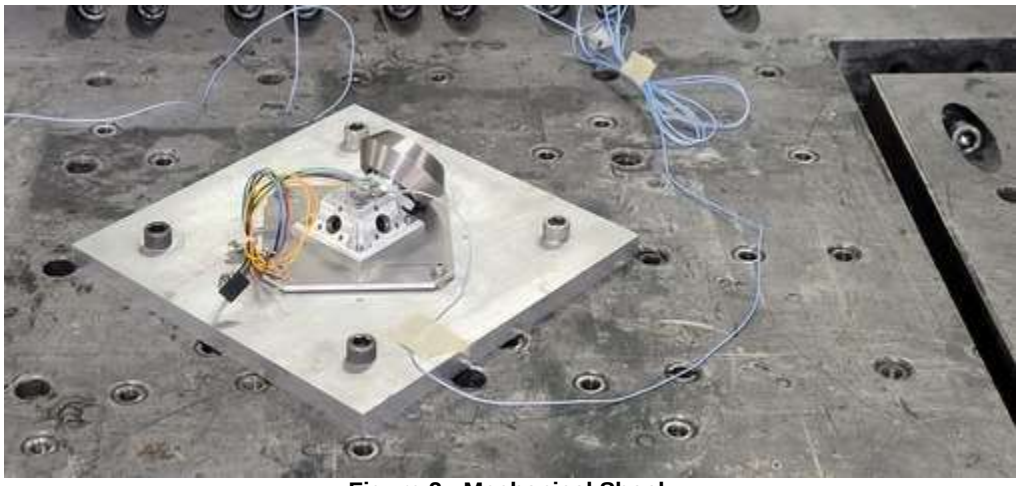

**Figure 2 - Mechanical Shock**

**Figure 3 - Mechanical Shock**

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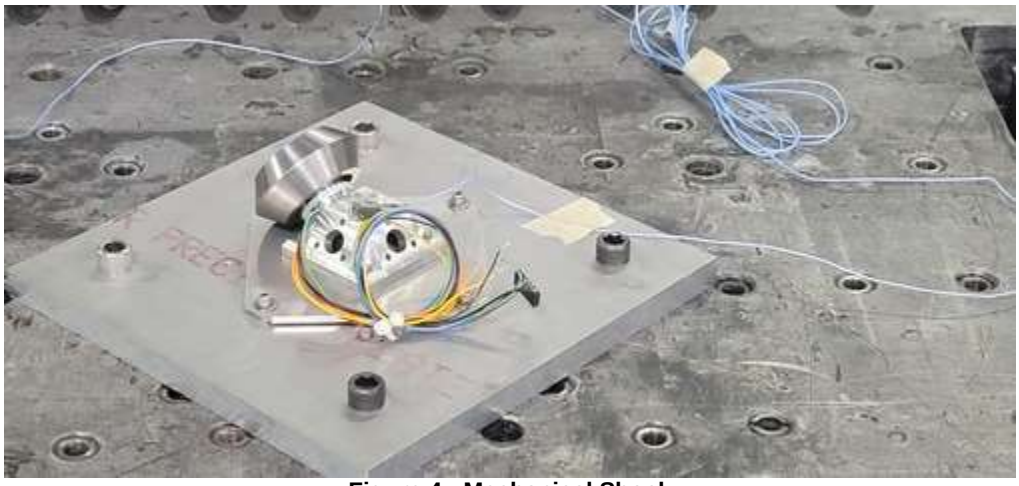

**Figure 4 - Mechanical Shock**

| | | |
|---|---|---|
| ETL | **Environmental Testing Laboratory, Inc Calibration Data** | ETL #1401 |

Environmental Testing Laboratory, Inc. is accredited by ANSI National Accreditation Board (ANAB) to ISO/IEC 17025:2017. Refer to Certificate of Accreditation and Scope of Accreditation Certificate Number: AT-1787. Certificate Valid Through 5/24/2023.

| | | | | |
|---|---|---|---|---|
| **Condition of instrument as received:** | | **X** | **Within tolerance** | **Instrument:** Vibration Research Controller |
| | | | **Out of tolerance** | **Manufacturer:** Vibration Research Corporation |
| | | | **Limited Use** | **Due Date:** 10/2/2021 |
| | | | **New** | **Calibration Date:** 10/1/2021 |
| X | **Internal Calibration** | | **External Calibration** | **Cal Freq:** 12 months |
| **Serial #:** 9505DD41 | | **Model #:** VR9500 Revolution | | **Next Cal Due:** 10/1/2022 |
| **ETL Calibration Procedure #:** 2.23-ETL-QS | | | | **Budget:** N/A |

**Calibrator and Additional Standards**

| ETL Asset # | Manufacturer | Model | Accuracy | Ch# | Uncertainty | Cert # | Cal Due Date |
|---|---|---|---|---|---|---|---|
| ETL #1358 | Agilent Technologies | 34401A | 0.0035 V | 1 | See Certificate | 1063-22 | 3/9/2022 |
| | | | | | | | |
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| | | | |
|---|---|---|---|
| **Ambient conditions during cal:** | **Barometric Pressure:** 29.56 **"Hg** | **Relative Humidity:** 68 **%** | **Temperature:** 26 **°C** |

| STD IN* | | | PRE CAL* | | POST CAL* | |
|---|---|---|---|---|---|---|
| **MU*** | **Channel #1** | **Channel #2** | **Channel #1** | **Channel #2** | **Channel #1** | **Channel #2** |
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Verification and calibration done internally with Vibration Research Inc. software. See attached Certificate of Calibration # 9505DD4120211001

**Measurement Uncertainty(1,2):**

MU* = Use for measurement uncertainty calculation, Y = Yes, N = No

Keegan Larimer

**Calibrated By:** Keegan Larimer

**Calibration Date:** 10/1/2021

# *Certificate of Calibration*

Certificate No.:9505DD4120211001

**Equipment:**

Manufacturer: Vibration Research Corporation
Item: VibrationVIEW I/O Box
**Serial Number: 9505DD41**

**Procedures used:**

VRC9555AC Rev.C as automated with Vibration Research software VR95-CAL.

**Environmental Conditions:**

Ambient Temperature: 26 C (23C +/- 5C)
Relative Humidity: 68 % (< 85%)

**Received Condition: In Tolerance**

**Shipped condition: Calibrated**

**Calibration:**

Calibration Date: Oct 1, 2021
Calibration Due: Oct 1, 2022
Calibration Technician: Keegan Larimer

**Parameters tested:**

See attached calibration table and graphs.

**Remarks or Special Requirements:**

Our calibration procedures are designed to provide measurement uncertainty of less than or equal to one quarter of the specification of the unit under test, where possible, with a coverage factor of 2. Traceability is to national standards administered by the U.S. NIST.

**Comments:**

None.

**Signature:**

Keegan Larimer

List of Test Equipment

| Meter Brand / Model | Serial Number | Trace Number | Due Date |
|---|---|---|---|
| HEWLETT-PACKARD 34401A | US36223701 | 1063-22 | 3/9/2022 |

| | | |
|---|---|---|
| ETL | **Environmental Testing Laboratory, Inc Calibration Data** | ETL #1534 |

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| | | | | | |
|---|---|---|---|---|---|
| **Condition of instrument as received:** | | **X** | **Within tolerance** | **Instrument:** PCB Piezotronics Accelerometer | |
| | | | **Out of tolerance** | **Manufacturer:** PCB Piezotronics | |
| | | | **Limited Use** | **Due Date:** 4/23/2022 | |
| | | | **New** | **Calibration Date:** 3/14/2022 | |
| X | **Internal Calibration** | | **External Calibration** | **Cal Freq:** 12 months | |
| **Serial #:** LW150726 | | **Model #:** 352A21 | | **Next Cal Due:** 3/14/2023 | |
| **ETL Calibration Procedure #:** 2.08-ETL-QS | | | | **Budget:** 0.95-1.05 G/G for 1-4000 Hz | |

**Calibrator and Additional Standards**

| ETL Asset # | Manufacturer | Model | Accuracy | Ch# | Uncertainty | Cert # | Cal Due Date |
|---|---|---|---|---|---|---|---|
| ETL #1674 | PCB Piezotronics | 301A11 | +/-0.5 % | 1 | 3.0 % | CAL20-3698664747.180+1, CAL96-3698684469.760+1 | 3/15/2022 |
| ETL #1400 | Vibration Research Corporation | VR9500 Revolution | 0.3 % | 1 | 0.3 % | 950663BE20211021 | 10/21/2022 |
| | | | | | | | |

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|---|---|---|---|
| **Ambient conditions during cal:** | **Barometric Pressure:** 29.59 **"Hg** | **Relative Humidity:** 47 **%** | **Temperature:** 22 **°C** |

| STD IN* | | | PRE CAL* | | POST CAL* | |
|---|---|---|---|---|---|---|
| **MU*** | **Channel #1** | **Channel #2** | **Channel #1** | **Channel #2** | **Channel #1** | **Channel #2** |
| | Calibration results fall within Budget limits. See Transmissibility Graph on attached Calibration Certificate. | | | | | |

**Measurement Uncertainty(1,2):**

MU* = Use for measurement uncertainty calculation, Y = Yes, N = No

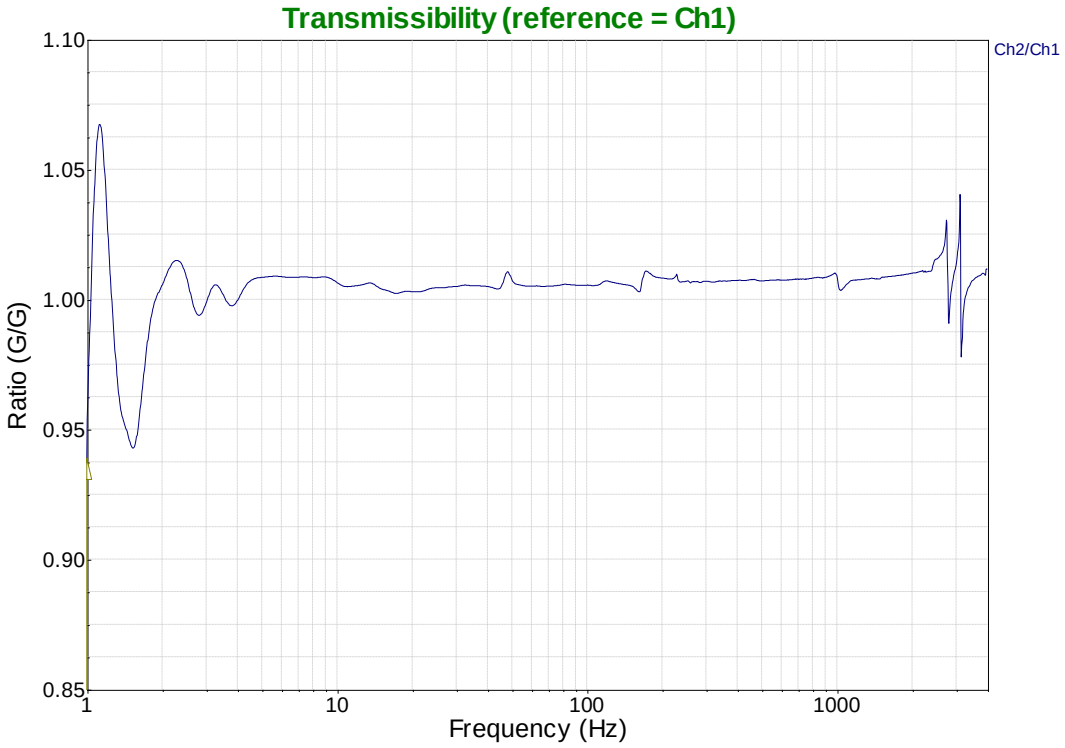
Keegan Larimer

**Calibrated By:** Keegan Larimer

**Calibration Date:**3/14/2022

# Calibration Certificate

| | |
|---|---|
| Report Date | 5/14/2022 |
| ETL Asset Number | 1534 |
| Model | 352A21 |
| Serial# | LW150726 |
| New Unit | |
| Re-Calibration | X |
| ● As Received | In Tolerance |
| ● As Returned | In Tolerance |
| Ref. Sensitivity | 10.18 mV/G |
| Remarks: | None. |



| | | |
|---|---|---|
| ETL | **Environmental Testing Laboratory, Inc Calibration Data** | ETL #1535 |

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| | | | | | |
|---|---|---|---|---|---|
| **Condition of instrument as received:** | | **X** | **Within tolerance** | **Instrument:** PCB Piezotronics Accelerometer | |
| | | | **Out of tolerance** | **Manufacturer:** PCB Piezotronics | |
| | | | **Limited Use** | **Due Date:** 4/23/2022 | |
| | | | **New** | **Calibration Date:** 3/13/2022 | |
| X | **Internal Calibration** | | **External Calibration** | **Cal Freq:** 12 months | |
| **Serial #:** LW150727 | | **Model #:** 352A21 | | **Next Cal Due:** 3/13/2023 | |
| **ETL Calibration Procedure #:** 2.08-ETL-QS | | | | **Budget:** 0.95-1.05 G/G for 1-4000 Hz | |

**Calibrator and Additional Standards**

| ETL Asset # | Manufacturer | Model | Accuracy | Ch# | Uncertainty | Cert # | Cal Due Date |
|---|---|---|---|---|---|---|---|
| ETL #1674 | PCB Piezotronics | 301A11 | +/-0.5 % | 1 | 3.0 % | CAL20-3698664747.180+1, CAL96-3698684469.760+1 | 3/15/2022 |
| ETL #1400 | Vibration Research Corporation | VR9500 Revolution | 0.3 % | 1 | 0.3 % | 950663BE20211021 | 10/21/2022 |
| | | | | | | | |

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|---|---|---|---|
| **Ambient conditions during cal:** | **Barometric Pressure:** 29.79 **"Hg** | **Relative Humidity:** 17 **%** | **Temperature:** 22 **°C** |

| STD IN* | | | PRE CAL* | | POST CAL* | |
|---|---|---|---|---|---|---|
| **MU*** | **Channel #1** | **Channel #2** | **Channel #1** | **Channel #2** | **Channel #1** | **Channel #2** |
| | Calibration results fall within Budget limits. See Transmissibility Graph on attached Calibration Certificate. | | | | | |
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**Measurement Uncertainty(1,2):**

MU* = Use for measurement uncertainty calculation, Y = Yes, N = No

Keegan Larimer

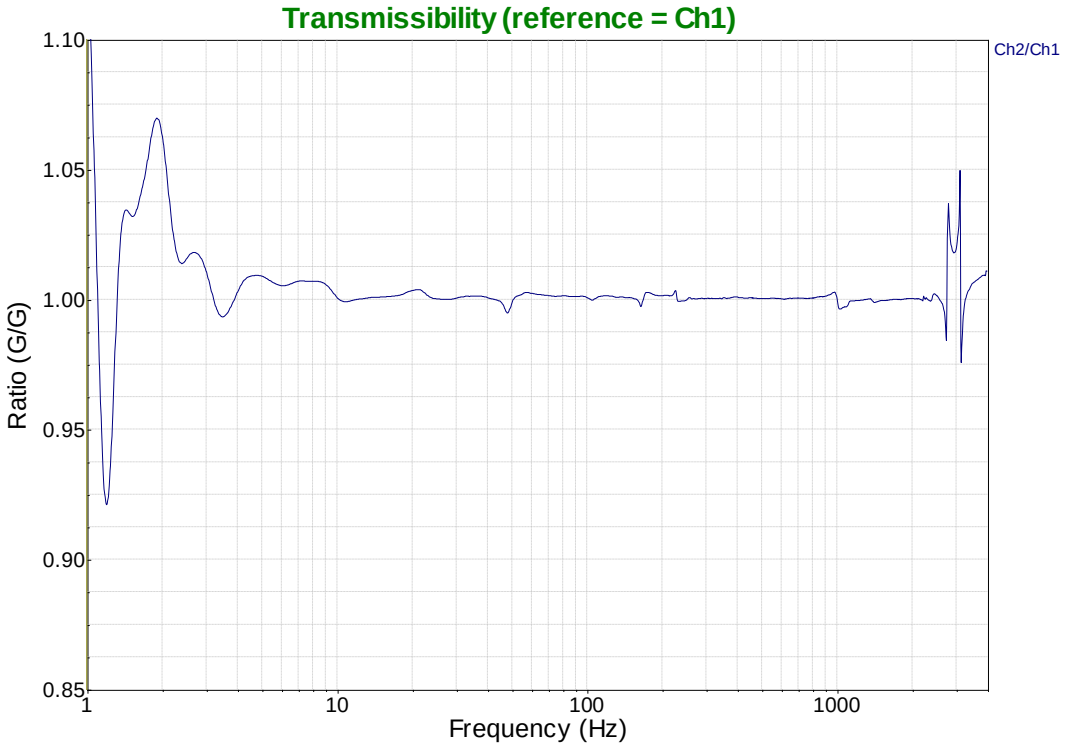
**Calibrated By:** Keegan Larimer

**Calibration Date:**3/13/2022

**Environmental Testing Laboratory, Inc.**

# Calibration Certificate

| | |
|---|---|
| Report Date | 3/13/2022 |
| ETL Asset Number | 1535 |
| Model | 352A21 |
| Serial# | LW150727 |
| New Unit | |
| Re-Calibration | X |
| ● As Received | In Tolerance |
| ● As Returned | In Tolerance |
| Ref. Sensitivity | 10.18 mV/G |
| Remarks: | None. |



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|---|---|---|
| ETL | **Environmental Testing Laboratory, Inc Calibration Data** | ETL #1717 |

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| | | | | | |
|---|---|---|---|---|---|
| **Condition of instrument as received:** | | | X | **Within tolerance** | **Instrument:** PCB Piezotronics Accelerometer |
| | | | | **Out of tolerance** | **Manufacturer:** PCB Piezotronics |
| | | | | **Limited Use** | **Due Date:** 11/4/2021 |
| | | | | **New** | **Calibration Date:** 11/4/2021 |
| X | **Internal Calibration** | | **External Calibration** | | **Cal Freq:** 12 months |
| **Serial #:** LW351177 | | **Model #:** 352A21 | | | **Next Cal Due:** 11/4/2022 |
| **ETL Calibration Procedure #:** 2.08-ETL-QS | | | | | **Budget:** 0.95-1.05 G/G for 1-4000 Hz |

**Calibrator and Additional Standards**

| ETL Asset # | Manufacturer | Model | Accuracy | Ch# | Uncertainty | Cert # | Cal Due Date |
|---|---|---|---|---|---|---|---|
| ETL #1674 | PCB Piezotronics | 301A11 | +/-0.5 % | 1 | 3.0 % | CAL20-3698664747.180+1, CAL96-3698684469.760+1 | 3/15/2022 |
| ETL #1415 | Vibration Research Corporation | VR9500 Revolution | 0.3% | 1 | 0.2% | 950776D120210504 | 5/4/2022 |
| | | | | | | | |

| | | | |
|---|---|---|---|
| **Ambient conditions during cal:** | **Barometric Pressure:** 29.84 **"Hg** | **Relative Humidity:** 38 **%** | **Temperature:** 22 **°C** |

| STD IN* | | | PRE CAL* | | POST CAL* | |
|---|---|---|---|---|---|---|
| **MU*** | **Channel #1** | **Channel #2** | **Channel #1** | **Channel #2** | **Channel #1** | **Channel #2** |
| | Calibration results fall within Budget limits. See Transmissibility Graph on attached Calibration Certificate. | | | | | |

**Measurement Uncertainty(1,2):**

MU* = Use for measurement uncertainty calculation, Y = Yes, N = No

Keegan Larimer

**Calibrated By:** Keegan Larimer

**Calibration Date:** 11/4/2021

**Environmental Testing Laboratory, Inc.**

# Calibration Certificate

| | |
|---|---|
| Report Date | 11/4/2021 |
| ETL Asset Number | 1717 |
| Model | 352A21 |
| Serial# | LW351177 |
| New Unit | |
| Re-Calibration | X |
| ● As Received | In Tolerance |
| ● As Returned | In Tolerance |
| Ref. Sensitivity | 10.15 mV/G |
| Remarks: | None. |