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ASE 16 Channel Multiplexer  
And A/D Converter Specification

*R. MILEY*  
*BxA/MSC*

PERFORMANCE/DESIGN  
AND  
PRODUCT CONFIGURATION  
REQUIREMENTS

16 CHANNEL MULTIPLEXER AND 8 BIT A/D CONVERTER  
FOR THE ACTIVE SEISMIC EXPERIMENT OF THE  
APOLLO LUNAR SURFACE EXPERIMENTS PACKAGE SYSTEM

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1.0 SCOPE

1.1 This specification covers the design, manufacturing, and testing requirements for a 16-channel multiplexer and analog to digital converter (herein after referred to as M and A/D) to be used as a part of the Active Seismic Experiment of the Apollo Lunar Surface Experiments Package (ALSEP) system.

2.0 APPLICABLE DOCUMENTS

2.1 The following documents of issue shown form a part of this specification to the extent specified herein. Should conflicting requirements exist, the requirements of this specification shall govern.

SPECIFICATIONS

Military

- |                                |   |
|--------------------------------|---|
| MIL-E-5272C (1)<br>(Section 3) | Environmental Testing, Aeronautical and Associated Equipment, General Specification for |
| MIL-W-8604                     | Welding of Aluminum Alloys, Processes for   |
| MHB 5300.4 (3A)                | Quality requirement for hand-soldering of electrical connections                        |

STANDARDS

Military

- |              |   |
|--------------|---|
| MIL-STD-130B | Identification Marking of U. S. Military Property |
|--------------|---|



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STANDARDS (Continued)

MIL-STD-810B	Environmental Test Methods for Aerospace and Ground Equipment
MS33586A	Metals, Definition of dissimilar
MSC-ASPO-EMI-10A	NASA Addendum to specification MIL-I-2660
OTHER PUBLICATIONS	
ATM 241	Acceptable Parts List (Latest Revision)
ATM 242	Approved Materials List (Latest Revision)
AL-770000	ALSEP EMI Specification
BSX 1000	Quality and Workmanship Requirements
Bendix Drawings	
2346702	Electrical and Mechanical Interface.

NASA/MSC CRITERIA AND STANDARDS

DS-5	Transistors - Selection of Types
DS-25	Wire Bundles - Protective Coatings
PS-5	Protection of Electrical/Electronic Assemblies from Moisture Damage
PS-6	Ultrasonic Cleaning Electrical and Electronic Assemblies
PS-8	Application of Previous Qualification Tests
PS-11	Direct Procurement of Parts
DS-22	Flammability of wire bundles

3.0 REQUIREMENTS



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3.1 Performance

The M and A/D shall gate on demand any one of the sixteen analog signals. Three of these will be designated to carry the outputs of the ASE geophones. In addition, the M and A/D converter shall convert the analog voltage to binary form.

3.2 Configuration

The M and A/D shall consist of one sixteen channel multiplexer, and one 8-bit A/D converter.

3.3 Reliability

The reliability goal shall be 0.9999 as a minimum for all mission phases including the following:

- Launch
- Transit
- Lunar landings and deployment
- One year non-operation on lunar surface
- Thirty hours functional lunar operation

Provision shall be made to minimize the effect of failure of any channel on an operating geophone channel. It is essential that at least 2 out of 3 geophone channels are functioning in order to obtain meaningful ASE data.

3.3.1 Maintainability

Accessibility and interchangeability features shall be incorporated into the design to allow efficient servicing and maintenance.

3.4 Environmental Requirements

The M and A/D shall be capable of performing as specified herein during or after, as applicable, being subjected to the most severe environmental conditions shown herein or any logical combination of these environments applied simultaneously. The most severe environment values shown herein are minimum design requirements. Test shall be in accordance with Standard MIL-STD-810 as applicable and Section 3 of Specification MIL-E-5272.



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The M and A/D converter will be qualified and accepted to the levels shown herein.

- |  |   |
|--|---|
| (a) Temperature (Operating)              | Qualification Testing: $-22^{\circ}\text{F}$ to $+158^{\circ}\text{F}$<br>Acceptance Testing: $-10^{\circ}\text{F}$ to $+146^{\circ}\text{F}$   |
| (b) Temperature (non-operating)          | Design: $-65^{\circ}\text{F}$ to $+200^{\circ}\text{F}$<br>Qualification Testing: Not required<br>Acceptance Testing: Not required  |
| (c) Shock (non-operating)                | Qualification Testing: 20 G-peak/11MSEC sawtooth per MIL-STD-810B<br>Acceptance Testing: Not required   |
| (d) Sinusoidal Vibration (non-operating) | Qualification Testing: See Figure 3<br>Acceptance Testing: Not required   |
| (e) Random Vibration (non-operating)     | Qualification Testing: See Figure 4 & 5<br>Acceptance Testing: Not required   |
| (f) Random Vibration (Operating)         | Qualification Testing: See Figure 6<br>Acceptance Testing: See Figure 6   |
| (g) Humidity                             | Qualification Testing: Not required<br>Acceptance Testing: Not required<br>General Testing: 50% relative maximum (operating)  |
| (h) Thermal-vacuum (operating)           | Design: $-22^{\circ}\text{F}$ to $+158^{\circ}\text{F}$ at less than $1 \times 10^{-12}$ mm of Hg.<br>Qualification Testing: $-22^{\circ}\text{F}$ to $+158^{\circ}\text{F}$ at less than $1 \times 10^{-5}$ mm of Hg.<br>Acceptance Testing: $-10^{\circ}\text{F}$ to $+146^{\circ}\text{F}$ at less than $1 \times 10^{-5}$ mm of Hg. |



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3.5 Safety

Safety requirements will comply with the following:

3.5.1 Personnel Safety

The M and A/D shall be designed to avoid sharp edges, corners and protuberances.

3.5.2 Hazard Proofing

The design of the M and A/D shall minimize the hazard of fire, explosion and toxicity to the crew, launch area personnel and facilities. The hazards to be avoided include accumulation on leakage of combustible gases, the hazard of spark or ignition including static electricity discharge, and toxicity due to inhalation or spillage of volatile or poisonous expendables. The requirements of DS-22 shall apply.

3.5.3 Fail Safe

Part, component or subsystem failures shall not propagate sequentially. With occurrence of failure, operation, will be maintained in a preferred mode where practical.

3.6 Interface Requirements

3.6.1 Schematic Requirements

The M and A/D electrical interface is indicated schematically in Figure 1.

3.6.2 Detailed Interface Definition

The M and A/D interfaces are divided into an electrical interface, a mechanical interface, and a thermal interface.



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3.6.3 Electrical Interface

3.6.3.1 Input signal characteristics

Amplitude                    0V to +5V  
Impedance                    < 10 K

3.6.3.2 Gating Signals

Each multiplexer channel shall be controlled by an external logic signal. These signals will be 0.0V to 0.4V to turn a channel ON, and 2.5V to 5.5V to turn a channel OFF. The maximum sink current into the output for the '0' level shall be 2 mA. The load for the '1' level shall not have an impedance of less than 5 K ohms.

The M and A/D shall be capable of operating with control signals as shown in Figure 2.

3.6.3.3 Crosstalk

Crosstalk between channels shall not exceed  $\pm 0.1\%$  of maximum input voltage.

3.6.3.4 Input Impedance

The input impedance of each channel shall be greater than 1 M ohm during the sampling period, and greater than 50 M ohms during the non-sampling period.

3.6.3.5 Overvoltage Protection

The M and A/D shall operate correctly as specified in paragraph 3.6.3.8 during an overvoltage of  $\pm 12V$  on any input line whether the channel is ON or OFF.



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3.6.3.6 Start Pulse

A pulse to start the conversion cycle shall be provided, and shall have the following characteristics:

Amplitude		5.5V to 2.5V
Width		100 + 5 $\mu$ s
Fall Time	<	200 ns
Rise Time	<	700 ns
Driving Capability		2 mA at logical '0'

3.6.3.7 Output Signals

The output of the M and A/D shall be digital and have the following characteristics:

Type of Output	Parallel Word
Resolution	8 bits
Logic Levels	Logical 1: 5.5V to 2.5V with a maximum source current of 100 $\mu$ a Logical 0: 0 to +0.4 with a maximum sink current of 2 mA

3.6.3.8 The output shall be a straight binary code and shall be scaled to the following specifications:

Output		Input Signal
00000000	=	negative input voltage
00000001		not less than 0V
11111111	$\geq$	+5 V
l. s. b.	=	0.019685 V

3.6.3.9 Accuracy of conversion of M and A/D

The maximum errors shall be:

Quantizing error		$\pm$ 1/2 bit
Analog error	<	$\pm$ 0.33% of 5V





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3.6.3.10 Conversion Time

The data shall be available to be read out 160  $\mu$ 's after the negative going edge of the start pulse.

3.6.3.11 Power

The following voltage supplies shall be provided as described below:

Voltage	Regulation	% Ripple	Max Power
+15 V	2%	0.4%	245 mW
-12 V	5%	0.4%	200 mW
+5 V	5%	0.4%	225 mW

The maximum total power available shall be no greater than 750 mW.

3.6.4.1 Mechanical Interface

The multiplexer and converter shall be capable of being mounted on a 1/4 inch aluminum plate with no more than six No. 6 flat head screws. The mounting plate shall have a flatness of 0.03 inches per foot.

3.6.4.2 Thermal Interface

The M and A/D shall thermally conduct heat through the flat aluminum mounting plate which shall be at a temperature of between  $-10^{\circ}$  F and  $+140^{\circ}$  F.

3.6.4.3 Voltage Polarity Reversal

Where practical, the M and A/D shall be designed to reduce the possibilities of damage, by a reversal of primary voltage polarity.

3.6.4.4 Power Distribution

Power distribution voltage below the nominal operating voltage shall not damage equipment.



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3.7 Mechanical Requirements

3.7.1 Size

The M and A/D shall not exceed 11.6 cubic inches. However, design emphasis shall be made on small volume.

3.7.1.2 Weight

The M and A/D shall not exceed 0.55 pounds maximum. However, design emphasis shall be made to reduce weight as far as practical.

3.7.1.3 Form Factor

The form factor of the multiplexer and converter shall be governed by the Interface Control Drawing, Bendix Drawing No. 2346702.

3.7.2 Quality Assurance Provisions

3.7.2.1 Materials, Parts and Processes

Materials shall be selected from the ALSEP Approved Material List - ATM-242. Parts shall be selected from the Acceptable Parts List - ATM-241. All parts and materials shall be compatible with the intended use and environment requirements specified in 3.3., 3.4, and 3.5 herein.



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3.7.2.3 Materials

Materials used in the fabrication of all components shall be of the highest quality compatible with design requirements specified herein. In general, the following types of material shall not be used without prior written approval of NASA:

- (a) Flammable materials
- (b) Toxic materials
- (c) Unstable materials
- (d) Plastic - Only epoxy resin-based compounds, teflon, and mylar shall be used. Acrylic base compounds can be used for component castings.
- (e) Dissimilar metals in direct contact which tend toward active electrolytic or galvanic corrosion.

3.7.2.4 Standard Processes

3.7.2.4.1 Protective Treatment

All materials used which are not inherently corrosive-resistant shall be treated to resist any corrosive effects resulting from environmental conditions specified herein. Protective coatings shall not crack, chip, peel, or scale with age when subjected to the environmental extremes specified. The requirements of PS-5 shall apply prior to protective treatment. The requirements of DS-25 also apply if wire bundles are coated.

3.7.2.4.2 Soldering

NASA Publication NHB 5300.4 (3A) shall apply for hand soldering of all electrical connections.

3.7.2.4.3 Welding

Of Aluminum Alloy: Process for MIL-W-8604.



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3.7.2.4.5 Ultrasonic Cleaning

The requirements of PS-6 shall apply.

3.7.3.1 Standardization

Maximum economic standardization of parts and components shall be provided. Where identical or similar functions are performed in more than one application within the system, effort shall be made to use only one item design for all system applications.

3.7.3.2 Parts Procurement

The requirements of PS-8 and paragraphs (a) and (b) of PS-11 shall apply.

3.7.3.3 Transistors

The requirements of DS-5 shall apply.

3.7.4 Moisture and Fungus Resistance

Materials which are not nutrients for fungus shall be used whenever possible. The use of materials which are nutrients for fungus shall not be prohibited in hermetically sealed assemblies and in other accepted and qualified uses such as paper capacitors and treated transformers. If it is necessary to use fungus nutrient materials in other than such qualified application, these materials shall be treated with a process which will render the resulting exposed surface fungus resistant.

3.7.5 Corrosion of Metal Parts

Metal shall be corrosion-resistant type or suitably treated to resist corrosive conditions likely to be met in storage or normal service. Unless suitably protected against electrolytic corrosion, dissimilar metals, as defined in Standard MS 33586, shall not be used in direct physical contact.



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3.7.6 Interchangeability and Replaceability

Interchangeability and replaceability shall be compatible with the requirements of paragraph 3.3.1 herein. Items of equipment with the same part numbers shall be physically and functionally interchangeable.

3.7.7 Workmanship

The M and A/D shall be constructed, finished, and assembled in accordance with BSX 1000.

3.7.9 Electromagnetic Interference (EMI)

All items furnished shall have as a design goal the intent of meeting the requirements of Bendix AL-770000 ALSEP EMI Specification.

3.7.9.1 Operation

Electrical and electronic equipment shall perform as specified herein when operating either independently or in conjunction with other equipment with which there are electrical connections, or which may be installed nearby. This requires that the operation of such equipment shall not be adversely affected by interference voltages and fields reaching it from external sources and also requires that such equipment shall not, in itself, be a source of interference which might adversely affect the operation of other equipments. These general criteria ensure that the system will meet the requirements of the overall system acceptance criteria, and electromagnetic compatibility as specified in the performance specifications. In addition to these general requirements, the system shall satisfy the requirements of paragraph 3.4 and NASA Addendum MSC-ASPO-EMI-10A.



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3.7.9.2 Transient Interference

Transient or short duration interference resulting from the operation of electrical or electromechanical devices shall not compromise the performance requirements as specified herein.

3.7.9.3 Interference-Free Design

Interference control shall be considered in the basic design of all subsystem electronic and electrical equipment and specialized equipment such as simulation sources and GSE. The design shall be such that, before interference control components are applied, the amount of interference internally generated and propagated shall be the minimum achievable. The application of interference control components (e.g., filtering, shielding, bonding) shall conform to good engineering practice and, wherever practical, shall be an integral part of the subsystem or component.

3.7.9.4 Power and Signal Grounding

All DC power and signal returns shall be isolated from component or subsystem chassis by 1 megohm.

3.7.9.5 Filtering

Wherever practical, filters shall be provided at each component or subsystem, as required, to prevent internally generated electrical interference signals being conducted out of the component or subsystem.

3.7.10 Identification and Marking

The multiplexer/converter shall be marked for identification in accordance with Standard MIL-STD-130.



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3.7.10.1 Identification and Marking Data

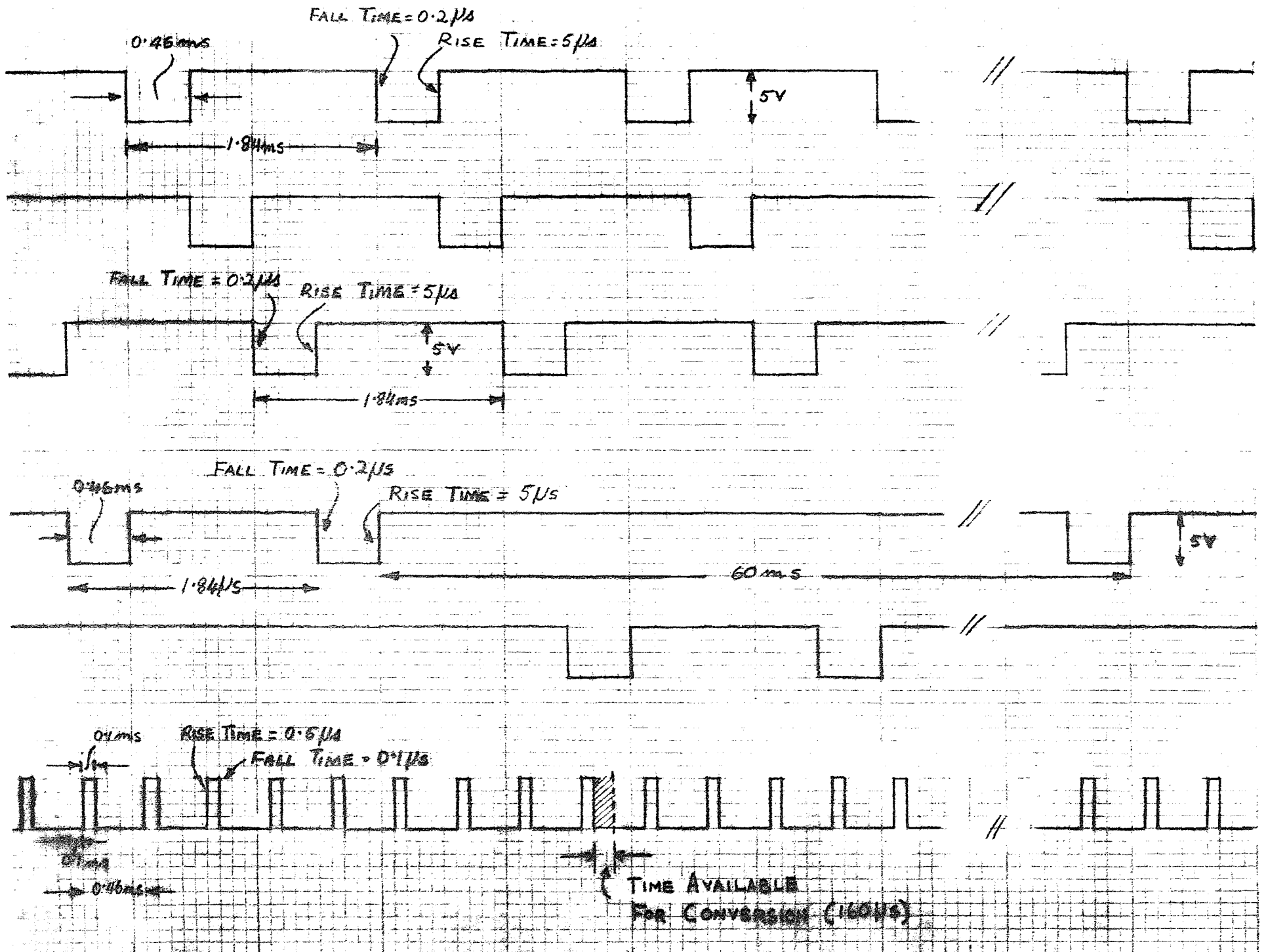
Identification and marking shall include but not be limited to the following data:

- (a) Item nomenclature
- (b) Item part number
- (c) Item serial number

3.7.11 Storage

The M and A/D shall have a shelf life of 2 years. Shelf life is defined as a storage period in a controlled environment of 10°C to 30°C and a relative humidity of no more than 50% following acceptance and prior to installation in the LM for flight.

FIG 2: TIMING DIAGRAM OF THE GATING PULSES FOR THE 16-CHANNEL MUX.



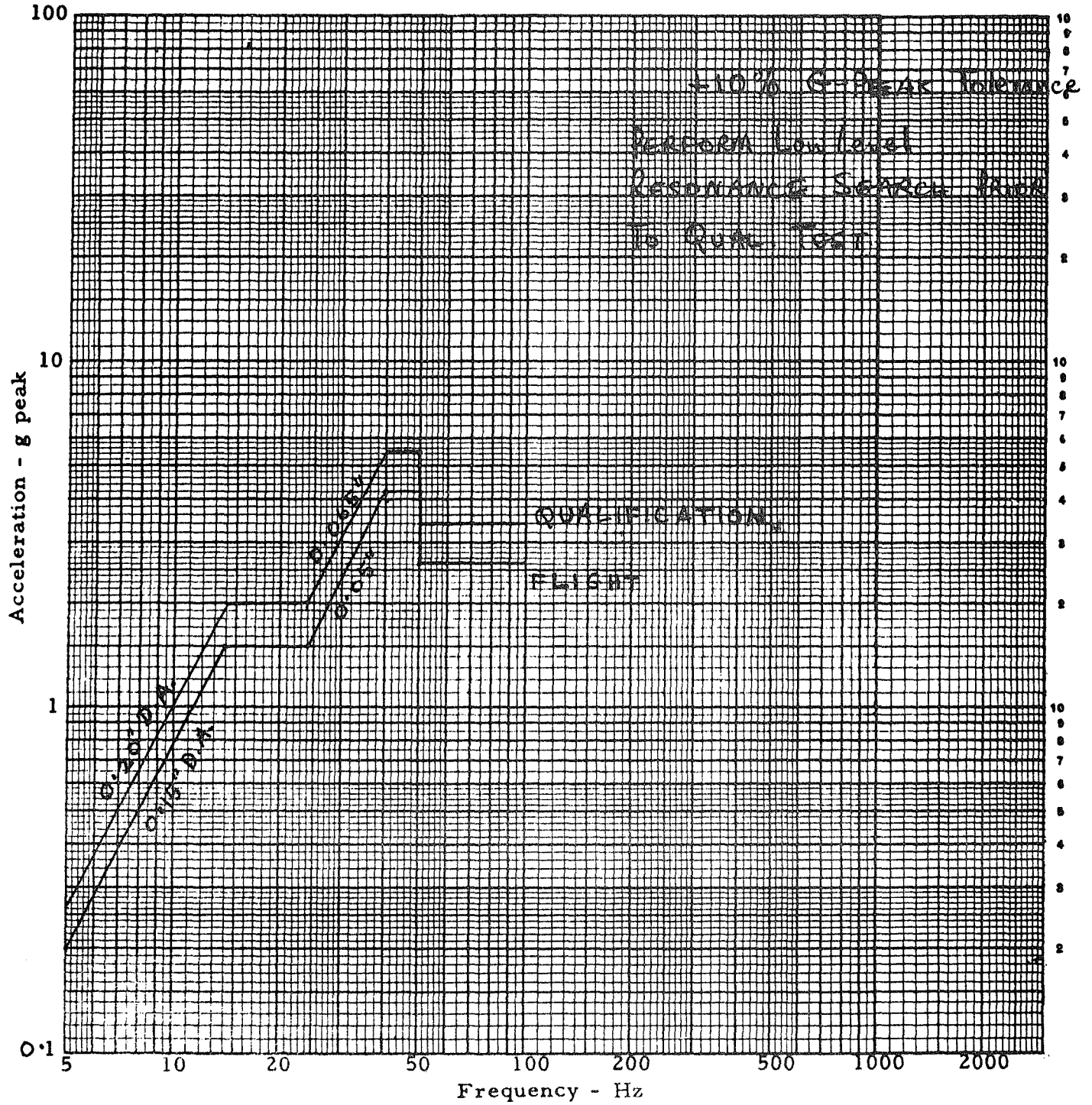


SYSTEMS TEST DEPARTMENT

# SINUSOIDAL VIBRATION LEVELS

Test Item: ASE  
 Test Date:  
 SWEEP RATE: 3/4 OCTAVES PER MIN.

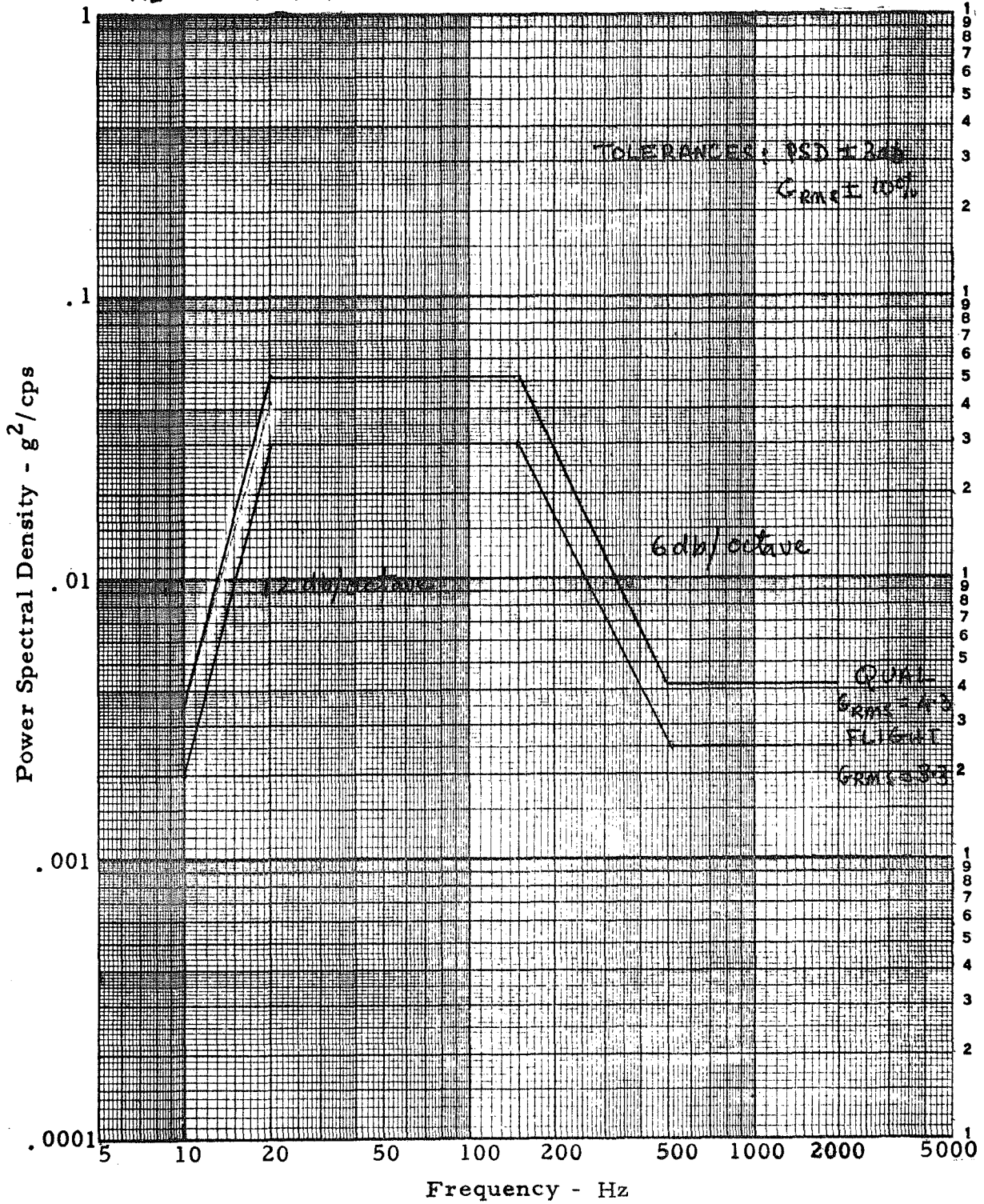
Serial Number:  
 Input Axis:  
 Response Axis: X, Y & Z



RANDOM VIBRATION SPECTRUM

Test: ASE M and A/D  
Test Item: NON-OPERATING  
Test Date:  
TIME: 12.5 min.

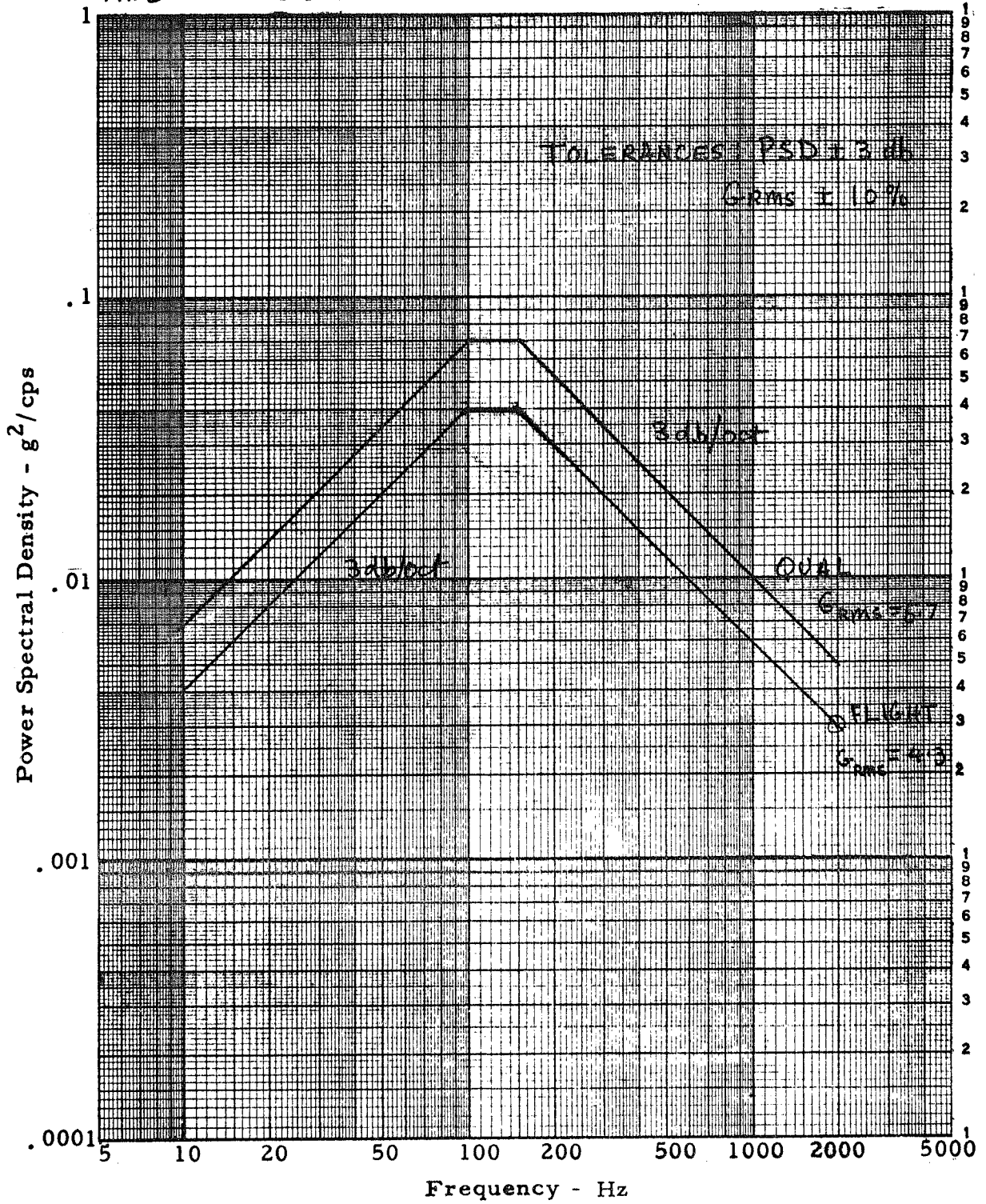
SN:  
Axis: X, Y+Z



RANDOM VIBRATION SPECTRUM

Test: ASE M + A/D  
 Test Item: NON-OPERATING  
 Test Date:  
 Time: 2.5 min

SN:  
 Axis: X, Y, Z



RANDOM VIBRATION SPECTRUM

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Test: ASE M and ND  
Test Item: OPERATING  
Test Date:  
TIME (QUALIFICATION): 5 min  
(ACCEPTANCE): 1 min

SN:  
Axis: X, Y+Z

