MILITARY SPECIFICATION

DYNAMIC REFERENCE UNIT (DRU)

This specification is approved for use within the U.S. Army Armament, Munitions and Chemical Command and is available for use by all Departments and agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers a self contained inertial surveying system for use in weapon and target acquisition systems.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards and handbooks. The following specifications, standards and handbooks form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

MILITARY

MIL-S-5002	-	Surface Treatment and Inorganic Coatings for Metal Surfaces of Weapons Systems.
MIL-B-5087	-	Bonding, Electrical and Lightning Protection for Aerospace Systems.
MIL-E-6051	-	Electromagnetic Compatibility Requirements, Systems.
MIL-H-6875	-	Heat Treatment of Steel, Processes for.
MIL-M-7793	-	Meter, Time Totalizing.
MIL-P-11268	-	Parts, Materials and Processes Used in Electronic Communications Equipment.
MIL-F-13926	-	Fire Control Material, Manufacture and Inspection, General Specification for.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, U.S. Army Armament, Munitions and Chemical Command, Attn. AMSMC-QA, Picatinny Arsenal, New Jersey 07806-5000 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 1220

MIL-F-14072	-	Finishes for Ground Electronic Equipment.
MIL-P-14232	-	Parts, Equipment and Tools for Army Material, Packaging of.
MIL-P-19834	-	Plate, Identification or Instruction, Metal Foil, Adhesive Backed, General Specification for.
MIL-C-38999	-	Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded, and Breech Coupling), Environment Resistant, Removable Crimp and Hermetic Solder Contacts, General Specification for.
MIL-C-46168	-	Coating, Aliphatic Polyurethane, Chemical Agent Resistant.
MIL-H-46855	-	Human Engineering Requirements for Military Systems, Equipment and Facilities.

STANDARDS

MILITARY

MIL-STD-105	-	Sampling, Procedures and Tables for Inspection by Attributes.
MIL-STD-109	-	Quality Assurance Terms and Definitions.
MIL-STD-130	-	Identification Marking of U.S. Military Property.
MIL-STD-454	-	Standard General Requirements for Electronic Equipment.
MIL-STD-461	-	Electromagnetic Emission and Suspectibility Requirements for the Control of Electromagnetic Interference.
MIL-STD-462	-	Electromagnetic Interference Characteristics, Measurements of.
MIL-STD-463	-	Definition and Systems of Units, Electromagnetic Interference Technology.
MIL-STD-781	-	Reliability and Design Qualification and Production Acceptance Tests: Exponential Distribution.
MIL-STD-810	-	Environmental Test Methods and Engineering Guidelines.
MIL-STD-1275	-	Characteristics of 28 Volt DC Electrical Systems in Military Vehicles.
MIL-STD-1472	-	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MIL-STD-1474	-	Noise limits for Army Materiel.
MIL-STD-1750	-	Military Standard Sixteen-Bit Computer Instruction Set Architecture.

MS18012	-	Handles, Metal, Spring-Bail Type.
MS27467	-	Connector, Plug, Electrical Straight, Crimp Type, Bayonet Coupling, Series I.
MS27468	-	Connector, Receptacle, Electrical Jam Nut Mounting, Crimp Type, Bayonet Coupling Series I.

2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this specification to the extent specified herein. Unless otherwise specified, the issues shall be those in effect on the date of the solicitation.

DRAWINGS

MILITARY

78020	-	Microcircuits, Linear Quad Differential Line Receivers, Monolithic Silicon.

PUBLICATIONS

OSIL No. 72	-	Ordnance Survey Information Leaflet No. 72, Transverse Mercator Projection, Constants, Formulae and Methods.
TECOM Report 86-LR(V)-41 24 Sep 86	-	Firing Test of M109E4 Howitzer.
TECOM Report 86-LR(V)-41 10 Mar 87	-	Firing Test of M109E4 Howitzer.
TECOM Report 87-LR(V)-2 28 Jan 87	-	Road Shock and Vibration Test of M109E4 Howitzer.
TECOM Report 87-LR(V)-1 14 Jan 87	-	Road Shock and Vibration Test of MAPS Hardware in M113A1.

Manuals

F M 3-4	-	Nuclear-Biological-Chemical (NBC) Protection.
F M 3-5	-	Nuclear-Biological-Chemical (NBC) Decontamination.
F M 5-241-8	-	Universal Transverse Mercator Grid.

Nuclear & Chemical

Nuclear Survivability Criteria for the Modular Azimuth Position System (MAPS), equipment survivability category: man in truck or signal shelter, equipment exposed.

NBC Contaminants Survivability Criteria for Army Materiel.

(Copies of specifications, standards, handbooks, drawings, publications, and other Government documents required by the contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity).

2.2 Non-Government documents. The following documents of the exact issue shown forms a part of this specification to the extent specified herein. In the event of conflict between the document referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

EIA RS-422	-	Electronic Industries Association (EIA) Standard RS-422, Electrical Characteristics of Balanced Voltage Digital Interface Circuits. Electronic Industries Association, 2001 Eye Street NW, Washington, DC 20006
ANSI Y 14.5M	-	Dimensioning and Tolerancing. American National Standards Institute, 1430 Broadway, New York, NY 10018-3308
Z8030/8530 SCC	-	Zilog Serial Communitions Controller Technical Manual, Zilog Inc., 210 Hacienda Avenue, Cambell, CA 95008-6609

Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets, or MS Standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First article. When specified, a sample shall be subjected to *first article inspection* (See 4.6 and 6.3).

3.2 Qualification. DRUs furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list at the time set for opening of bids (See 4.5 and 6.4).

3.3 Fabrication. The Dynamic Reference Unit shall be manufactured in accordance with this specification and figures included in this specification.

3.4 General specification. The contractor shall be responsible for compliance to the requirements of paragraphs 4.2.2.1 to 4.2.2.3 of specification MIL-F-13926.

3.5 Item definition.

3.5.1 Item functions. The DRU shall be a self-contained inertial surveying system for use in U.S. Army weapon and target acquisition systems. The DRU shall provide, depending on the application, all or part of the following:

a. Horizontal Position in Universal Transverse Mercator (UTM) coordinates of northing, easting, hemisphere and zone.
b. Horizontal Position in British National Grid coordinates of northing and easting.
c. Altitude.
d. Angular Orientation consisting of DRU Grid Azimuth or Geodetic Azimuth, DRU Pitch and DRU Roll.
e. Angular Orientation consisting of Pointing Device Grid Azimuth or Geodetic Azimuth, Pointing Device Pitch and Pointing Device Cant.
f. Angular Orientation consisting of Vehicle Grid Azimuth or Geodetic Azimuth, Vehicle Pitch and Vehicle Roll or Cant.
g. Angular Velocity consisting of DRU Azimuth Rate, DRU Pitch Rate and DRU Roll Rate.
h. Angular Velocity consisting of Pointing Device Azimuth Rate and Pointing Device Pitch Rate.

Coordinate and reference frames shall be as defined in 6.6.

The DRU shall accept the following types of damping to improve inertial survey accuracy:

a. Odometer.

b. Zero-velocity updates (ZUPTs) when vehicle is stopped.

The DRU will be used in configurations in which both types of damping will be available, i.e., continuous odometer pulses when the vehicle is moving and ZUPTs whenever the vehicle is stopped. When a Vehicle Motion Sensor (VMS) is not used in the configuration, or odometer data is unavailable because of a malfunction, or when the system is commanded, periodic zero-velocity vehicle stops at regular intervals will be used to provide damping. This mode of operating shall be invoked automatically if odometer data becomes unavailable or erroneous because of a malfunction.

The DRU shall be interchangeable from prime system and vehicle to vehicle without requiring hardware changes, calibration procedures, vehicle driving constraints or unscheduled ZUPTS.

3.5.2 Configurations in which the DRU will be used. Several possible system applications for the DRU are depicted in Figures 1, 2, and 3. Figure 1 is an odometer aided inertial survey system with a Control and Display Unit (CDU) used for system control, data entry, and data display. Figure 2 shows a similar survey system with control, entry and display functions shared between the CDU and prime system equipment. In this configuration, the prime system can limit the ability of the CDU to control the DRU and enter data. Figure 3 is a zero-velocity aided inertial survey system without odometer input.

3.5.3 Operating modes. The DRU shall have two main operating modes: Align and Survey. Requirements and specifications for the two main operating modes are given in the following subparagraphs.

Throughout this document setting of an ALERT (30.4.6) or BUILT-IN-TEST (30.4.7) bit also implies setting the appropriate STATUS bit (30.5). Whenever the DRU is specified to set an ALERT DATA bit, the DRU shall also set bit 1 of STATUS character S2 and shall not reset bit 1 until all ALERT DATA bits have been reset. Whenever the DRU is specified to set a BUILT-IN-TEST bit, the DRU shall also set bit 5 of STATUS character S2 and shall not reset bit 5 until the failure has been corrected.

3.5.3.1 Align. The DRU shall have three align submodes: Normal Align, Stored Heading Align, and Realign. During Stored Heading Align and Realign the vehicle will be stationary. During Normal Align the vehicle will usually be stationary during the entire alignment, but may be moved after 3.5 minutes with degraded survey accuracies.

3.5.3.1.1 Initialization. Within 20 seconds after application of power or after receipt of a RESTART command, except where noted, the DRU shall:

a. Set bit 7 of STATUS character S1 (Exception: Bit 7 shall remain reset for RESTART).

b. Initiate BIT of itself, and if there is a failure, set bit 7 of BUILT-IN-TEST DATA character D1.

c. Check if last shutdown was abnormal, and if so, set bit 0 of ALERT DATA character D1 and bit 1 of STATUS character S1 (Exception: These bits shall not be set again for RESTART if reset criteria were met and they were previously reset).

d. If a VMS is being used, initiate hardware BIT of the VMS. (Not required after receipt of a RESTART command if VMS BIT already has been performed). If there is a failure, set bit 1 of BUILT-IN-TEST DATA character D2, and bit 3 of STATUS character S1. If the VMS passes BIT, reset bit 3 of STATUS character S1.

e. If a VMS is not being used, set bit 3 of STATUS character S1.

f. Set bit 4 of STATUS character S2 to indicate that the pointing device is in the travel lock position. (Exception: Travel lock discrete indicates that the pointing device is out of travel lock or an OUT OF TRAVEL LOCK command has been received).

g. Respond to commands within 10 seconds after turn-on.

h. Reset bit 7 of STATUS character S1 when the DRU is ready to proceed to Normal Align (Already reset for RESTART).

i. Set bit 5 of STATUS character S1 when the DRU enters Normal Align.

j. Set bit 0 STATUS character S2 to indicate that the first 5 minutes of Normal Align has started.

k. Set bit 7 of STATUS character S2 to indicate that a zero-velocity update has been initiated.

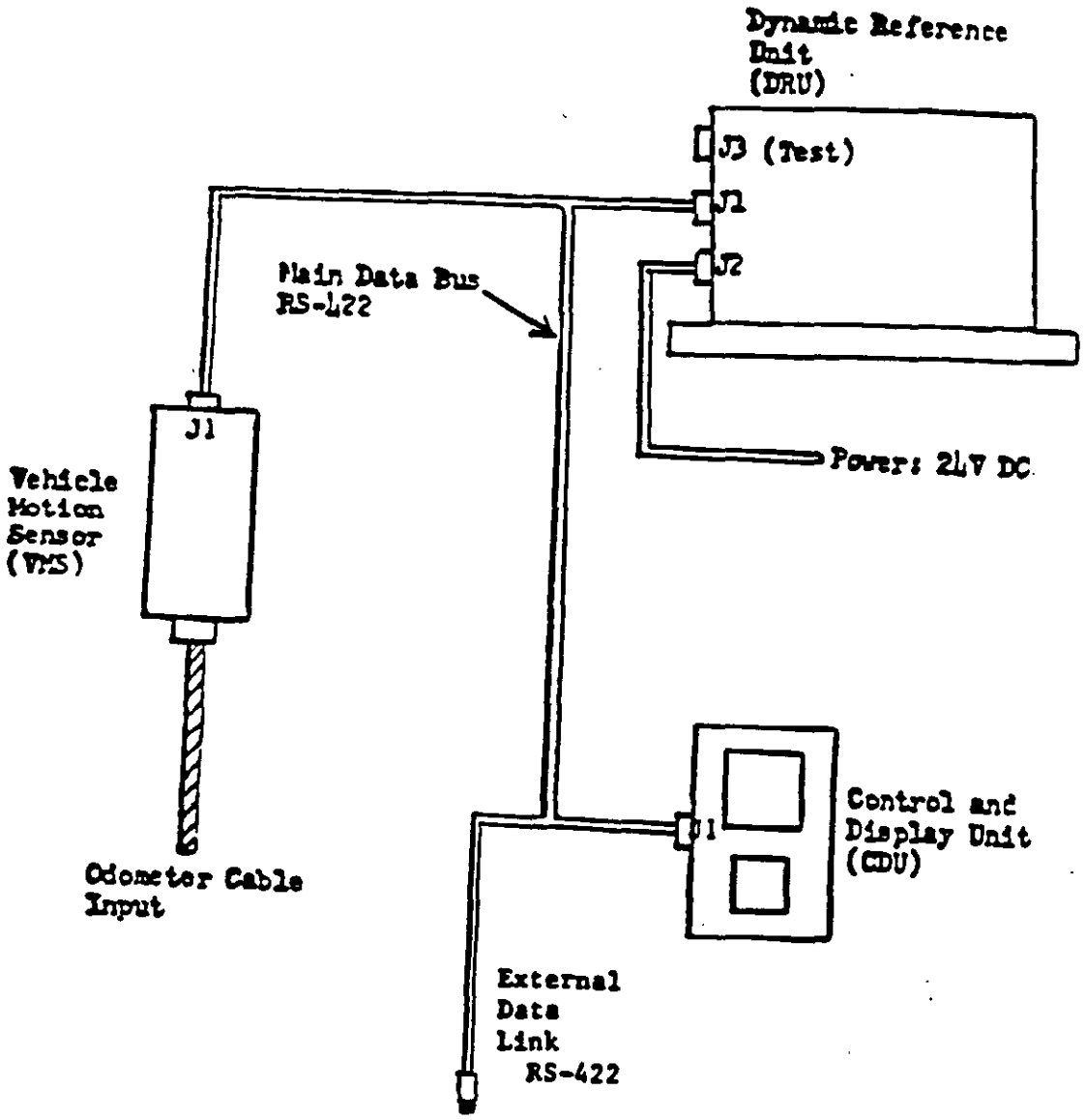
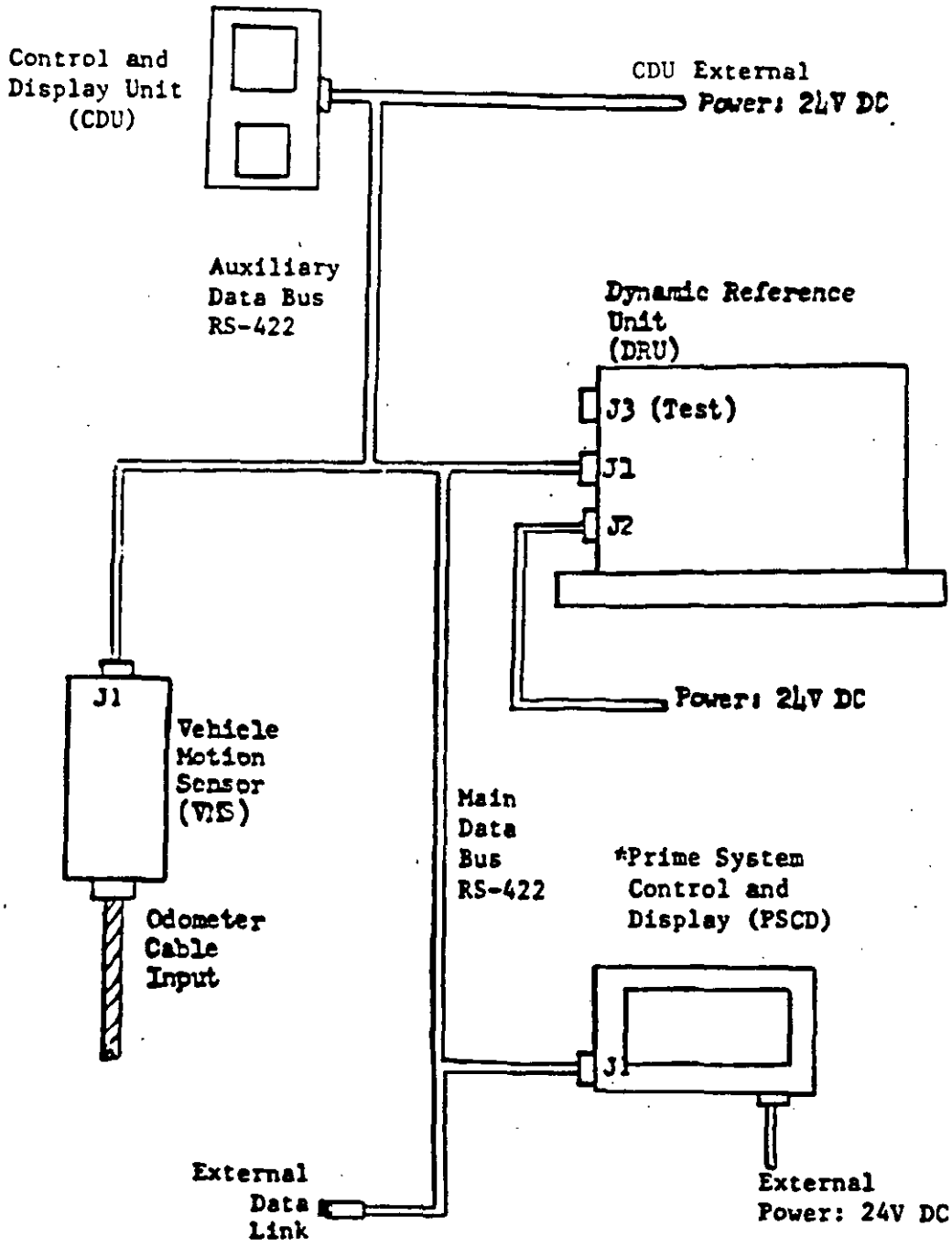


FIGURE 1: Configuration A
Odometer Aided Inertial Survey System



*Prime system may be disconnected from DRU during mission while power is still on.

FIGURE 2: Configuration B
Odometer Aided-Prime System Connected to Main Data Bus, Control and Display Unit Connected to Auxiliary Data Bus.

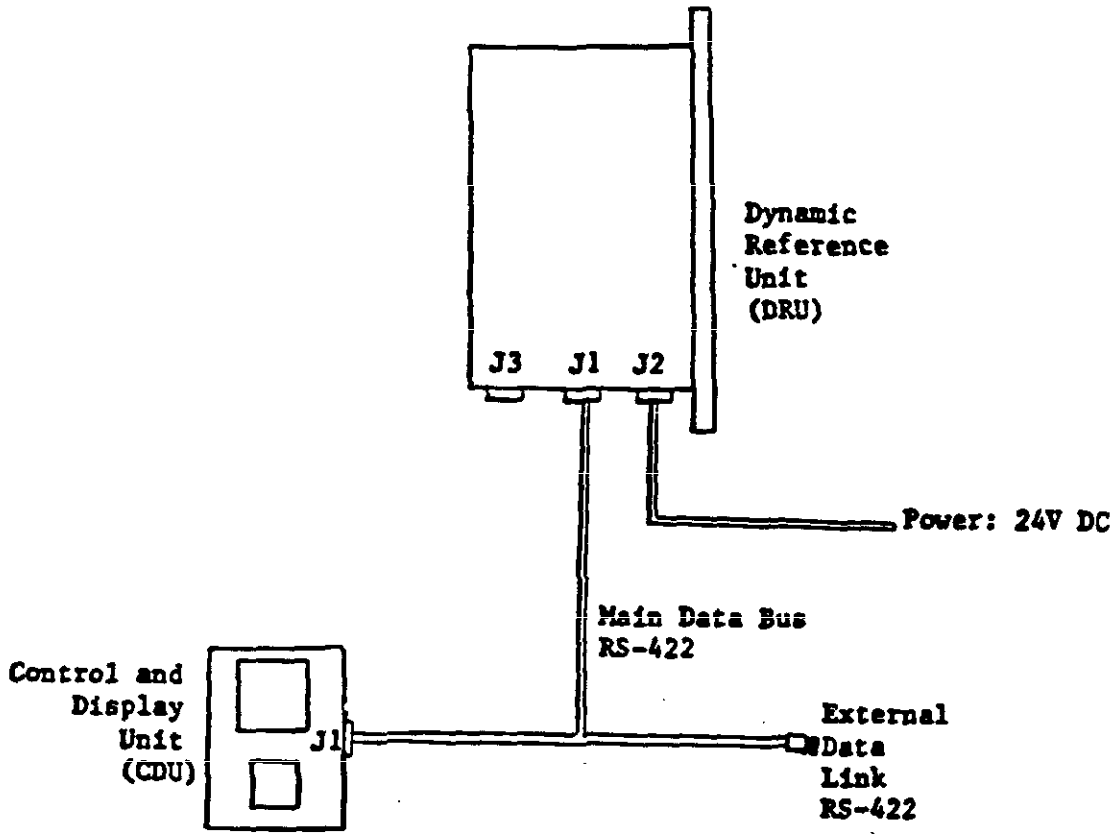


FIGURE 3: Configuration C
MAPS System Without Odometer Aiding (ZUPT Mode)

l. If initial parameters have not been received, set bit 6 of ALERT DATA character D2.

m. Be ready to accept and process initial parameters if they are input, via the ACCEPT POSITION command.

3.5.3.1.1.1 Absence of abnormal shutdown. If there has not been an abnormal shutdown (30.4.6.D1/0), the DRU shall accept initial parameters at anytime during Normal Align if acceptance criteria are met. Up to the time new parameters are accepted the DRU shall use the current stored position.

If initial parameters are input, the DRU shall perform reasonableness checks as specified in 3.10.5. If criteria in 3.10.5 are not met, the DRU shall reject the data, set the appropriate alerts as specified in 3.10.5 and continue Normal Align using current stored position. If, subsequently initial parameters are not input and accepted, when Normal Align is complete, bit 6 of DATA character D2 shall be reset.

If initial parameters are input and pass reasonableness checks as specified in 3.10.5, the DRU shall accept the data and reset bit 6 of ALERT DATA character D2.

If initial parameters are not input at anytime during Normal Align, the DRU shall use current stored position, and at the completion of Normal Align shall reset bit 6 of ALERT DATA character D2.

3.5.3.1.1.2 Abnormal shutdown. If there has been an abnormal shutdown (30.4.6.D1/0) , the DRU shall accept initial parameters at anytime within the first 3.5 minutes of Normal Align if acceptance criteria in 3.10.5 are met. On acceptance of the initial parameters, the DRU shall automatically RESTART and reset bit 6 of ALERT DATA character D2 and bit 0 of ALERT DATA character D1. If initial parameters are not received and accepted within the first 3.5 minutes of Normal Align, bit 5 of STATUS character S1 shall be reset and bit 4 of STATUS character S1 shall remain reset. When both bits 4 and 5 of STATUS character S1 are reset, the proper operator response will be to command RESTART, and update position.

3.5.3.1.2 Normal Align. In the Normal Align mode, the DRU shall automatically align the navigation coordinate frame by determining the direction of the gravity vector and gyrocompassing. Normal Align shall be accomplished without entry of external orientation data. The DRU shall enter the Normal Align mode automatically after power turn on. The DRU shall also enter the Normal Align mode on receipt of the RESTART command (30.3.3) if the DRU is stationary. Otherwise, bit 6 of ALERT DATA character D3 shall be set and the DRU shall remain in the present mode. Bit 5 of STATUS character S1 and bit 0 of STATUS character S2 shall be set and bit 4 of STATUS character S1 shall be reset when the DRU enters the Normal Align mode.

During the first 3.5 minutes of Normal Align, and only during the first 3.5 minutes of Normal Align, if excessive vehicle motion is detected or the vehicle prematurely proceeds on its mission, bit 3 of ALERT DATA character D2 shall be set, bit 5 of STATUS character S1 shall be reset, and bit 4 of STATUS character S1 shall remain reset. (When both bits 4 and 5 of STATUS character S1 are reset, the proper operator response will be to command RESTART.) After the first 3.5 minutes of Normal Align have been completed, bit 4 of STATUS character S1 shall be set and bit 5 of STATUS character S1 shall remain set until Normal Align is completed.

If Normal Align is completed with the vehicle parked at one location for 15 minutes, the DRU shall meet the survey accuracies specified in 3.6.1.1. The vehicle may move after being in the Normal Align mode for 3.5 minutes. In which case, bit 2 of STATUS character S1 shall be set after each 3 minutes, 45 seconds of travel until a total of 15 minutes, plus 30 seconds for each travel period, of align time have been accumulated with the vehicle stopped. Vehicle stops of less than 30 seconds or periods in which motion disturbances are present shall not count toward align time. If Normal Align is completed at the next vehicle stop, the DRU shall meet the survey accuracies specified in 3.6.1.1. If Normal Align is completed at more than one subsequent vehicle stop, or if vehicle travel time exceeds 4 minutes between stops, the DRU shall meet the Normal Align and survey azimuth accuracies in 3.6.1.1, but until a position update is performed, shall not be required to meet the position accuracy in 3.6.1.1. If the vehicle fails to stop every 4 minutes to complete Normal Align, bit 1 of STATUS character S1 shall be set.

When 5 minutes of Normal Align have been completed, bit 0 of STATUS character S2 shall be reset.

Prior to completion of Normal Align, an input reasonableness test as described in 3.10.6.1 shall be performed. If the test is not passed, bits 4 and 5 of STATUS character S1 shall be reset and bit 4 of ALERT DATA character D2 shall be set.

When Normal Align is complete, bit 5 of STATUS character S1 shall be reset, and bit 6 of ALERT DATA character D2 shall be reset (if it has not already been reset).

3.5.3.1.3 Stored Heading Align. The DRU shall enter the Stored Heading Align mode on receipt of the STORED HEADING ALIGN command (30.3.8) at any time within the first 60 seconds of Normal Align. However, if the STORED HEADING ALIGN command is received more than 60 seconds after the start of Normal Align, or if the previous shutdown was abnormal, or if there has been a previous RESTART, or if bit 3 of ALERT DATA, character D2 is set, the DRU shall not enter the Stored Heading Align mode and shall set bit 6 of ALERT DATA character D5. Bit 2 or STATUS character S2 shall be set, bit 0 of STATUS character S2 shall be reset, and bit 6 of ALERT DATA character D2 shall be reset when the DRU enters the Stored Heading Align mode. The Stored Heading Align mode shall use the last stored values of position coordinates and azimuth at the time of shutdown. If the DRU receives an ACCEPT POSITION command while in the Stored Heading Align mode, the DRU shall reject the data and set bit 7 of ALERT DATA character D5. At the successful completion of 90 seconds of Stored Heading Align, the DRU shall automatically enter the Survey mode, reset bit 2 of STATUS character S2, set bit 4 of STATUS character S1, and reset bit 5 of STATUS character S1.

The DRU shall automatically revert to Normal Align and set bit 5 of ALERT DATA character D2 if it determines that the stored heading is invalid. The DRU shall make this determination by comparing stored DRU pitch and roll to current DRU pitch and roll values and stored DRU azimuth to the DRU azimuth determined after coarse gyrocompass. The stored value heading also shall be considered invalid if excessive vehicle motion is detected during Align. Bit 2 of STATUS character S2 shall be reset when the DRU enters either the Survey or Normal Align mode.

After having successfully completed Stored Heading Align and entered the Survey mode, the DRU may enter the ZUPT mode until a total of 5 minutes of stopped time has been accumulated. After 5 minutes of stopped time has accumulated, the DRU automatically shall transition to the Odometer mode if the Odometer Mode/Exclusive ZUPT Mode Configuration Flag is set.

3.5.3.1.4 Realign. In the Realign mode, the DRU automatically shall restore its alignment to meet the accuracy requirement of 3.6.1.1 without any external entry of DRU orientation and when subjected to normal motion induced by engine idling, wind buffeting, etc. Realignment shall not be required more frequently than once every two hours to meet the positioning accuracies specified in 3.6.1.1. The DRU shall enter the Realign mode on receipt of the REALIGN command (30.3.9), if the DRU is stationary. Otherwise bit 6

of ALERT DATA character D3 shall be set, and the DRU shall remain in the Survey mode. If the DRU is moved during realignment, it shall be capable of continuing survey with no degradation in performance, i.e., the DRU shall perform the same as it would have if it had not been commanded to REALIGN. Bit 5 of STATUS character S1 shall be set when the DRU enters the Realign mode and shall be reset when Realign is complete or reset if excessive vehicle motion is detected. If excessive vehicle motion is detected, bit 3 of ALERT DATA character D1 shall also be set. During Realign bit 4 of STATUS character S1 shall remain set. Bit 6 of ALERT DATA character D5 shall be set if the DRU receives a REALIGN command while still in the Normal Align mode or Stored Heading Align mode.

3.5.3.2 Survey. During survey, the DRU shall provide position, orientation and angular rate parameters to the accuracies specified in 3.6.1.1. The DRU shall have two survey submodes: Odometer and ZUPT. The DRU shall determine when the vehicle moves and shall immediately set bit 6 of STATUS character S1. The DRU shall determine within 5 seconds when the vehicle is stopped and shall reset bit 6 of STATUS character S1. The DRU shall provide positions referenced to the spheriod designation stored/input during initialization. The DRU shall provide positions and grid azimuths in the British National Grid if the spheroid designation stored/input during initialization is No. 0. Otherwise the DRU shall provide UTM positions and grid azimuths in the normal zone or extended zone as designated by character D6 of the last received ACCEPT POSITION command (which may have been received prior to the last shutdown). An exception is when the Configuration Definition Flag for Azimuth (3.5.8.8g) is set. In which case the DRU shall provide positions in the British National Grid or UTM normal zone or extended zone, as designated, but azimuths shall be geodetic.

3.5.3.2.1 Positioning. When in the Survey mode, the DRU shall continuously determine position as it is moved. The DRU may be moved by movement of the transporting vehicle. While the vehicle is stationary or the DRU is operating in the ZUPT mode the DRU mounting surface may move with respect to the vehicle chassis. The DRU shall perform as specified herein with no external aiding except odometer signals or zero-velocity updates.

3.5.3.2.1.1 Zero-Velocity updates. The DRU shall utilize zero-velocity updates (ZUPTs) to control system errors. Zero-velocity updates shall be initiated automatically whenever the DRU determines that it is stationary. During survey, zero-velocity updates shall not exceed 30 seconds in duration from the time the vehicle is stopped. A zero-velocity update shall be terminated upon detection of excessive DRU motion. Early termination of a zero-velocity update shall not degrade DRU performance. A zero-velocity update is either fortuitous or mandated. It is fortuitous if it is initiated without a request from the DRU, i.e., when bit 2 of STATUS character

S1 is reset. It is mandated if it is initiated at the request of the DRU, i.e., when bit 2 of STATUS character S1 is set. When a mandated zero-velocity update is initiated, bit 2 of STATUS character S1 shall be reset. If excessive vehicle motion is detected, during the mandated zero-velocity update, bit 2 of STATUS character S1 and bit 1 of ALERT DATA character D2 shall be set. Bit 1 of ALERT DATA character D2 shall not be reset until a zero-velocity update is completed. Whenever a mandated or fortuitous zero-velocity update is initiated, bit 7 of STATUS character S2 shall be set and reset when the zero-velocity update is completed or interrupted. When either a mandated or fortuitous zero-velocity update has been completed, but the DRU remains stationary, the DRU shall initiate and attempt to complete additional zero-velocity updates. These additional zero-velocity updates shall be considered fortuitous.

In the Odometer Aided mode, the DRU shall not require zero-velocity updates more frequently than once per hour of travel time to meet the accuracies specified in 3.6.1.1.1 and 3.6.1.1.2. In the exclusive ZUPT mode, the DRU shall not require zero-velocity updates more frequently than once per every 4 minutes of travel time to meet the accuracies specified in 3.6.1.1.3 and 3.6.1.1.4.

In either the Odometer Aided mode or Zupt mode, the DRU shall inhibit zero-velocity updates on receipt of the INHIBIT ZERO-VELOCITY UPDATE command (30.3.12) and shall reinstate zero-velocity updates on receipt of the ENABLE ZERO-VELOCITY UPDATE command (30.3.13).

3.5.3.2.1.2 Exclusive ZUPT mode. If the Configuration Definition Flag for Odometer/ZUPT Mode is reset (3.5.8.8a), the DRU shall operate exclusively in the ZUPT mode and shall use periodic mandated zero-velocity updates to aid the inertial sensors. The DRU shall ignore the odometer signal inputs and shall perform neither VMS hardware or software built-in-test. Nor shall the DRU respond to the mode change commands, ZUPT MODE REQUEST and ODOMETER MODE REQUEST. Bit 3 of STATUS character S1 shall be set and remain set. Bit 2 of STATUS character S1 shall be set at the completion of each travel period specified for the ZUPT mode according to 3.5.8.5, and *reset when a zero-velocity update is initiated.*

3.5.3.2.1.3 Odometer mode. If the Configuration Definition Flag for Odometer/Exclusive ZUPT mode is set and the pointing device is in TRAVEL LOCK the DRU shall operate in the Odometer mode. Both acceptable VMS data and ZUPTs shall be used to aid the DRU when in the Odometer mode. The ZUPT request interval shall be as specified in Configuration data (3.5.8.5). Bit 2 of STATUS character S1 shall be set to request a ZUPT. Bit 3 of STATUS character S1 shall not be reset when the DRU is in the Odometer mode.

The DRU shall automatically transition from the Odometer mode to the ZUPT mode when the pointing device is out of TRAVEL LOCK.

In the Odometer mode, the DRU shall respond to the ODOMETER MODE REQUEST and ZUPT MODE REQUEST commands when the vehicle is stopped. If the vehicle is moving the DRU shall set bit 6 of ALERT DATA character D5.

When in the Odometer mode, to respond to ZUPT MODE REQUEST command, the DRU shall:

a. Enter the ZUPT mode.
b. Set bit 3 of STATUS character S1.
c. Not use VMS data to aid the inertial sensors.

When operating in the ZUPT mode, to respond to an ODOMETER MODE REQUEST command, the DRU shall:

a. Perform built-in-test of the VMS. If the VMS fails built-in-test the DRU shall remain in the ZUPT mode.
b. Enter the Odometer Aided mode.
c. Reset bit 3 of STATUS character S1.
d. Ignore invalid VMS data and use acceptable VMS data to aid the inertial sensors.
e. Reset bits 1 and 2 of BUILT-IN-TEST character D2 (if they are not reset).

The DRU shall automatically transition from the Odometer mode to the ZUPT mode when a VMS malfunction or a significant amount of erroneous VMS data is detected. When the VMS is determined to be faulty, the DRU shall:

a. Automatically enter the ZUPT mode.
b. Set bit 3 of STATUS character S1.
c. Not use VMS data to aid the inertial sensors.
d. Immediately set bit 2 of STATUS character S1.
e. Set bits 1 and 2 of BUILT-IN-TEST character D2.
f. Perform a VMS hardware built-in-test. If the VMS successfully passes hardware built-in-test, bits 1 and 2 of BUILT-IN-TEST character D2 shall remain set. If the VMS fails hardware built-in-test, bit 1 of BUILT-IN-TEST character D2 shall remain set and bit 2 of BUILT-IN-TEST character D2 shall be reset.

3.5.3.2.1.4 Odometer scale factor and boresight. The nominal odometer scale factor and nominal vehicle boresight angles will be furnished to the DRU as configuration data (3.5.8). No external calibrations shall be required prior to a mission for the DRU to perform as specified herein. During the performance of missions, the odometer scale factor may experience long and short term

variations from the nominal value resulting from changes in vehicle tire pressure, loading, wheel/track slippage, vehicle turns, and from terrain conditions. While the DRU to vehicle chassis alignment is usually stable within a survey leg, it may vary from one leg to the next because of equipment variations such as antennae being raised and stowed. Short term variations in DRU to direction of travel alignment may result from vehicle movement such as turning or crabbing.

3.5.3.2.2 Orientation. The DRU shall provide case orientation attitudes (DRU Grid Azimuth or Geodetic Azimuth, DRU Pitch, DRU Roll); vehicle orientation attitudes (Vehicle Grid Azimuth or Geodetic Azimuth, Vehicle Pitch, Vehicle Roll or Cant); and pointing device orientation attitudes (Pointing Device Grid Azimuth or Geodetic Azimuth, Pointing Device Pitch, Pointing Device Cant). The DRU shall output Geodetic Azimuth when the Configuration Definition Flag for azimuth is set (3.5.8.8g), and Grid Azimuth when the flag is reset. The DRU shall output Vehicle Roll when the Configuration Definition Flag For Vehicle cant/roll is set (3.5.8.8h), and Vehicle Cant when the flag is reset.

The DRU may be mounted to any part of a prime system needing orientation data. The DRU shall relate orientation attitudes to the prime system pointing device and vehicle coordinate frames as well as the DRU coordinate frame. The nominal values of the vehicle and pointing device boresight angles shall be defined for a particular installation/vehicle by configuration data (3.5.8.1 and 3.5.8.2).

The orientation attitudes may be used for navigation during the travel phase of a mission; emplacement of a prime system upon arrival at a site; precise orientation of a sensor or weapon during deployment; and automatic stowing of the sensor or weapon. The sensor or weapon, on which the DRU is mounted, may be elevated/rotated from its normal travel position during deployment as antennae are erected, weapons aimed, etc. The DRU shall be capable of Normal Align/Realign after being elevated/rotated from its normal travel position and shall continue to provide precise orientation data after prime system operations such as radar activation or weapon firing.

3.5.3.2.3 Angular rates. The DRU shall provide case orientation angular rates for three axes (DRU Azimuth Rate, DRU Pitch Rate, DRU Roll Rate). The DRU shall provide two pointing device rates (Pointing Device Azimuth Rate, Pointing Device Pitch Rate). To relate the DRU case orientation rates to the pointing device rates, the DRU shall use the pointing device boresight angles.

3.5.4 Electrical interface.

3.5.4.1 Connectors. Connectors shall conform to MIL-C-38999. Each external connector reference designation, part number, number of contacts, contact size, purpose of connector, and mating connector is defined in Table I. DRU signal connector J1 pin functions shall be in accordance with Table II. Terminations shall be as shown in Figure 4.

3.5.4.1.1 Shield grounding. Connecting cable external and internal shields will be grounded directly to the connector backshells. J1, J2 and J3 connector shells shall provide a path to the DRU chassis of less than 2.5 milliohms resistance from DC to 10 MHz.

TABLE I. DRU CONNECTOR INFORMATION

Connector Reference Designator	Connector Part Number (Chassis Conn)	Number of Contacts	Contact Size	Connector Purpose	Mates with
J1	MS27468T19F35S	66	22D	Signal	MS27467T19F35P
J2	MS27468T15F15P	14	20	Power	MS27467T15F15S
		1	16		
J3*	MS27468T19F35SB	66	22D	Test	MS27467T19F35PB
	MS27468T21F35SA	79	22D	Test	MS27467T21F35PA

*Contractor may select either listed connector for J3.

TABLE II. J1 PIN FUNCTION

PIN	FUNCTION	TERMINATION (See Fig. 4)
1	Auxiliary Clock (RS-422) - Hi	A
2	Spare	
3	Spare	
4	Auxiliary Data Bus (RS-422) - Hi	B
5	Auxiliary Clock (RS-422) - Lo	A
6	Spare	
7	Spare	
8	Main Clock (RS-422) - Hi	A
9	Main Clock (RS-422) - Lo	A
10	Auxiliary Data Bus (RS-422) - Lo	B
11	Spare	
12	On Power Control	

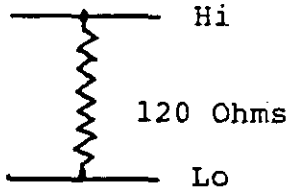
TABLE II. J1 PIN FUNCTION (Cont'd)

PIN	FUNCTION	TERMINATION (See Fig. 4)
13	On Power Control	
14	Signal Ground (for Config. Discrete)	
15	Spare	
16	Main Data Bus (RS-422) - Hi	B
17	Travel Lock Discrete (RS-422) - Hi	C
18	Travel Lock Discrete (RS-422) - Lo	C
19	Configuration Discrete 3	
20	Chassis Ground	
21	24 VDC Return	
22	24 VDC Return	
23	24 VDC Return	
24	Main Data Bus (RS-422) - Lo	B
25	Spare	
26	Signal Ground (for Config. Discrete)	
27	+ 15 VDC	
28	Configuration Discrete 4	
29	+ 15 VDC	
30	+ 5 VDC	
31	+ 5 VDC	
32	Signal Ground (for Config. Discrete)	
33	Configuration Discrete 1	
34	Spare	
35	Spare	
36	+ 5 VDC	
37	- 15 VDC	
38	- 15 VDC	
39	DC Return	
40	DC Return	
41	Signal Ground (for Config. Discrete)	
42	Configuration Discrete 2	
43	Spare	
44	Spare	
45	DC Return	
46	Spare	
47	Spare	
48	Spare	
49	VMS BIT Cmd 2 (RS-422) - Hi	
50	VMS BIT Cmd 2 (RS-422) - Lo	
51	Spare	
52	+ 24 VDC	
53	Odometer Reverse (RS-422) - Hi	C
54	Odometer Reverse (RS-422) - Lo	C
55	Spare	
56	Spare	
57	VMS BIT Cmd 1 (RS-422) - Hi	

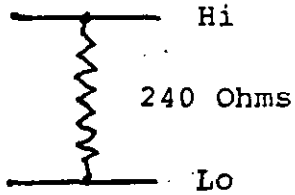
TABLE II. J1 PIN FUNCTION (Cont'd)

PIN	FUNCTION	TERMINATION (See Fig. 4)
58	+ 24 VDC	
59	+ 24 VDC	
60	Spare	
61	Spare	
62	Spare	
63	VMS BIT Cmd 1 (RS-422) - Lo	
64	Odometer Forward (RS-422) - Hi	C
65	Odometer Forward (RS-422) - Lo	C
66	Spare	

DETAIL A



DETAIL B



DETAIL C

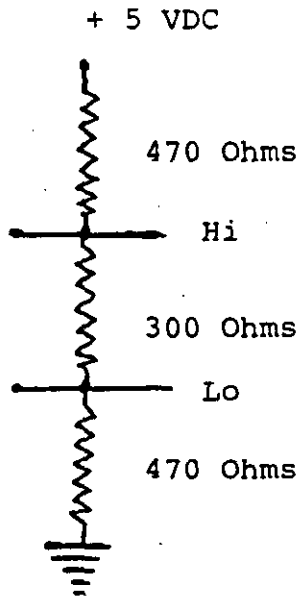


FIGURE 4 Terminations

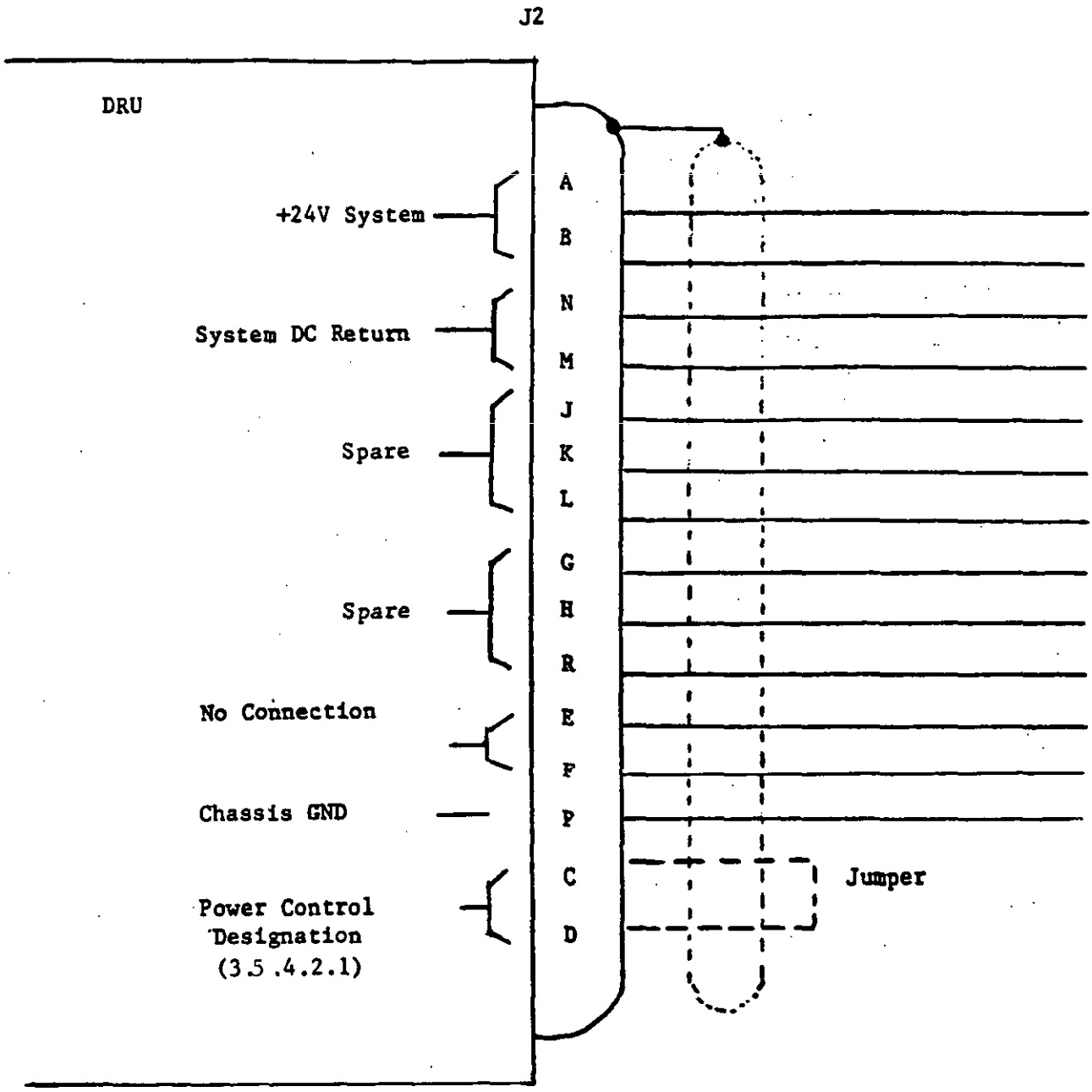
3.5.4.2 Power. The DRU shall turn on when activated (3.5.4.2.1) if the steady state power voltage meets the criteria specified herein. The DRU shall always turn on when the steady state power voltage is 18.5 VDC and at any value above 18.5 VDC up to and including 32.0 VDC. At the option of the contractor, the DRU may turn on when the steady state power voltage is 16.3 VDC and at any value above 16.3 VDC up to 35.0 VDC. Once on, the DRU shall not cycle off and on from IR voltage drop and shall operate as specified herein. The DRU shall not turn on when the steady state power voltage is less than 16.3 VDC or more than 35.0 VDC. The DRU shall always stay on when the steady state power voltage is 16.3 VDC and at any value above 16.3 VDC up to and including 32.0 VDC. At the option of the contractor, the DRU may stay on or turn off when the steady state power voltage is more than 15.0 VDC but less than 16.3 VDC or more than 32.0 VDC but less than 35.0 VDC. The DRU shall be off when the steady state power voltage is 15.0 VDC or less or 35.0 VDC or more.

The DRU shall operate as specified herein while operating from a power source functioning at the worst case limits of MIL-STD-1275, excepting initial engagement surges and cranking. The DRU shall not be damaged by input voltage polarity reversal. The DRU shall not be damaged by surges, spikes, ripple, starting disturbances or steady state voltages ($\leq$ 100 VDC) as specified in MIL-STD-1275 for normal operation, single fault conditions and multiple fault conditions. Loss of power shall not damage the DRU or affect the computer program or DRU calibration data. Special alignment procedures shall not be required after an unexpected power loss. Electrical overload protection shall be provided as specified in Requirement 8 of MIL-STD-454. Bonding of the DRU to the vehicle shall be in accordance with Class H of MIL-B-5087.

The power required for the DRU shall not exceed 150 watts including regulated power furnished to external devices (3.5.4.2.2.1), but not unregulated power (3.5.4.2.2.2).

Pin assignments for DRU power connector J2 shall be in accordance with Figure 5.

3.5.4.2.1 Power control. The method of power control shall be selected by means of a shorting jumper between pins C and D of J2. If no jumper is present, the DRU shall be activated upon application of system power and shall automatically initiate the startup and alignment sequence. With this type of power control the DRU shall deactivate with the removal of primary power; the receipt of a SHUTDOWN command shall only initiate storage of data. If a jumper is present between pins C and D of J2, the DRU shall be activated only by a momentary contact closure between pins 12 and 13 of J1 (Table II), and deactivated after receipt of a SHUTDOWN command. The voltage appearing on J1 pins 12 and 13 shall not exceed the input power voltage. The current flowing through J1 pins 12 and 13 shall not exceed 5.0 milliamperes.



NOTE 1: **All wires No. 20 AWG except** pin P is No. 16 AWG.

FIGURE 5. DRU External Power Wiring

3.5.4.2.2 Power from DRU to peripheral equipment.

3.5.4.2.2.1 Regulated. The DC voltage and current requirements listed below shall be supplied by the DRU for external use, when the DRU is activated (3.5.4.2.1).

Voltage	Current	Maximum Ripple
+15 VDC	350 mA	150 mV pk-pk
-15 VDC	350 mA	150 mV pk-pk
+5 VDC	700 mA	100 mV pk-pk

The voltage outputs shall be within ± 5 percent of the specified voltages including the effects of source and load regulation and ripple. Power supply outputs shall be protected from overloads and over voltages. The DRU shall not shutoff or indicate a failure when momentary current surges are required to charge capacitors, up to 5 microfarads in value, in external devices being powered by the DRU.

3.5.4.2.2.2 Unregulated. The DRU shall supply unregulated, 24 VDC, vehicle power for external use. This power output shall be activated only when the DRU is activated (3.5.4.2.1). The load power will not exceed 32 watts and the surge current shall not exceed 2.0 amperes. The DC returns, pins 21 through 23 in Table II, shall not connect to the DRU chassis at any point.

3.5.4.3 Internal test. Internal wiring and pin assignments for test connector J3 are at the discretion of the contractor. A contractor identification resistor shall be wired between pins 1 and 5 inside the DRU in accordance with Table III. J3 shall be covered by a cap which shall prevent contamination of the connector pins. The cap shall be secured to the DRU chassis to prevent loss.

TABLE III. CONTRACTOR IDENTIFICATION RESISTOR VALUES

Vendor	Resistance (Ohms ±5%)
Honeywell	4000
Kearfott	3000

3.5.4.4 Data interfaces. Data shall be transferred between the DRU and other prime system subsystems (such as CDU, VMS, or AFCS) via digital (two-state) signal circuits. Data will be formatted as binary coded digital data (commands and messages); pulse trains (serial data bus clocks and odometer signals); and a discrete (travel lock). The DRU shall be ready to receive or transmit data within 10 seconds of turn on.

3.5.4.4.1 Signal circuits. All signal circuits, except On Power Control (3.5.4.2.1) and programming discretes (3.3.5.8.9), which connect the DRU and other prime system subsystems, shall be balanced differential voltage circuits in accordance with EIA Standard RS-422. All line drivers shall comply with the generator electrical characteristics specified in RS-422. All receivers shall comply with the requirements of Military Drawing 78020 device type 02.

The DRU shall not be damaged or malfunction when signal circuits are connected or disconnected with power on or off.

3.5.4.4.1.1 Logic levels. A binary logic "1" or "set" condition shall be represented by a positive voltage on the "Hi" line with respect to the "Lo" line. A logic "0" or "reset" condition shall be represented by a positive voltage on the "Lo" line with respect to the "Hi" line.

3.5.4.4.2 Data bus characteristics. The DRU shall have two, independent, bi-directional, half-duplex, synchronous, serial data buses. The two buses are labeled Main and Auxiliary. All commands and messages shall be transferred between the prime system and DRU via the data buses. Either bus may be used separately or both may be used simultaneously. The electrical characteristics, data protocols and data formats are the same for both data buses. The only difference between the two buses is that DRU response to data entry and mode change commands received over the Auxiliary Bus can be inhibited by the prime system using the Main bus (3.5.4.4.3.5). The data rate shall be 38.4 kilobits per second. Each data bus input/output shall be in a receive mode unless data is being transmitted by that particular bus.

3.5.4.4.2.1 Data protocols. All serial data bus timing and data protocols shall be compatible with the Zilog Z8030 Serial Communication Controller (SCC) used in the normal Synchronous Data Link Control (SDLC) mode. Data shall change after the falling edge and be valid on the rising clock edge. Prior to transmission of a command or message, the Cyclic Redundancy Check (CRC) generator and checker in the SCC shall be preset to all "1"s.

3.5.4.4.2.2 Data encoding. All serial data bus data shall be encoded in the Non-Return-to-Zero (NRZ) format compatible with the Zilog Z8030 SCC.

3.5.4.4.2.3 Clock. The DRU serial data buses shall operate properly when provided with 38.4 KHz $\pm$ 0.01 percent, symmetrical squarewave clock signals compatible with the Zilog Z8030 SCC used in the normal SDLC mode.

3.5.4.4.3 Command and message characteristics. Commands to and messages from the DRU on either the Auxiliary or the Main Bus shall have the following characteristics:

a. The prime system shall be the bus master which initiates commands to the DRU (slave). The DRU shall respond to commands within 10 seconds after application of power.

b. The DRU shall not initiate a message without a request (command).

c. The DRU shall send a message in response to each command received. The message shall be returned only on the bus over which the command was received.

d. STATUS (30.5) and ALERT (30.4.6) indications applicable to only one data bus (i.e. improper command received, error detected, etc.) shall be returned only on the applicable bus.

e. Commands and messages shall be constructed of 8-bit bytes (designated as characters).

f. The data field shall be constructed of a variable number of characters from a minimum of zero to a maximum of 64. All other fields are of fixed character length.

g. Bit positions within a character are shown below:

most significant bit							least significant bit
7	6	5	4	3	2	1	0

h. The order of transmission over the bus shall be most significant character (8 bit byte) first. The least significant bit within the character shall be transmitted first. In multiple or single character data words which do not assign all of the bits available, the least significant bit or bits within the least significant character shall be the unassigned bit or bits.

3.5.4.4.3.1 Command and message format definition. Command and message formats are shown below:

F	C	D1 D2.....DN INPUT COMMAND TO DRU	E1 E2	F
F	I	S1 S2 D1 D2.....DN OUTPUT MESSAGE FROM DRU	E1 E2	F

DESCRIPTION OF SYMBOLS

a. F, Flag. A fixed sequence to indicate start or end of message (01111110), 8 bits.

b. C, Command. Binary code character defining required DRU response. Detailed descriptions of each command are found in Appendices A, B & C. The command word consists of 5 bits. This character also contains a message sequence number which is 3 bits.

MESSAGE SEQ. NO.	COMMAND
MSB	LSB
XXX	XXXXX
765	43210

A message sequence number is assigned to each command by the prime system device generating the command. The message identifier shall contain the same message sequence number in the response to a specific command. The complete message identifier can be used by the prime system to correlate responses with requests. If the DRU receives an undefined command or a command with an incorrect number of data characters, it shall send back a STATUS DATA message indicating an ALERT and set ALERT DATA character D5 bit 0.

c. D1, 2 .... N, Data. There may be 0 to 64 data characters per input command or output message. The number and contents of data characters are defined in Appendices A and D.

d. E1, E2, Error Detection Code Characters. The error detection code shall be a 16 bit Cyclic Redundancy Check (CRC) compatible with the synchronous data link control (SDLC) protocol as implemented in the Zilog 8030 serial communication controller (CRC-CCITT polynomial). Each message sent by the DRU shall contain the CRC code computed for the information being sent. Each command received by the DRU shall be tested for correct reception. If an error is detected, the DRU shall ignore the command, issue a STATUS DATA message indicating an Alert, and set ALERT DATA character D5 bit 0.

e. S1, S2 Status Word. The DRU shall send its STATUS with every output message. The STATUS word contains 16 bits. Each bit indicates the presence or absence of a particular mode or condition. 30.5 explains all of the STATUS conditions.

f. I, Identifier. The identification character indicates the type of message being returned from the DRU. Descriptions of each message are contained in Appendix D. The identifier is 5 bits. The identifier character also contains an echo of the command message sequence number which is 3 bits.

ECHO OF MESSAGE SEQ. NO.	IDENTIFIER
MSB	LSB
XXX	XXXXX
765	43210

g. X Symbol. An X indicates a binary "1" or "0" in a command or identifier character.

3.5.4.4.3.2 Commands. Command code 6 (00110) is available for use by contractors (30.2.12). Other commands are divided into three categories. These categories are:

a. Those commands that transfer data from the prime system or CDU to the DRU. Detailed descriptions of these commands and data are found in Appendix A. These commands are:

(1) ACCEPT POSITION (NAVIGATION UPDATE) (30.1.1)
(2) ACCEPT BORESIGHT (30.1.2)
(3) ACCEPT CONFIGURATION DATA (30.1.3)

b. Those commands that request transfer of data from the DRU to the prime system or CDU. Detailed descriptions of these commands are found in Appendix B. These commands are:

(1) RETURN DRU RATE DATA (30.2.1)
(2) RETURN CONFIGURATION DATA (30.2.2)
(3) RETURN STATUS (30.2.3)
(4) RETURN NAVIGATION DATA (30.2.4)
(5) RETURN ATTITUDE DATA (30.2.5)
(6) RETURN ALIGN TIME TO GO (30.2.6)
(7) RETURN ALERT DATA (30.2.7)
(8) RETURN BIT DATA (30.2.8)
(9) RETURN TRAVEL LOCK DATA (30.2.9)
(10) RETURN POSITION DATA (30.2.10)
(11) RETURN DRU ORIENTATION AND POINTING DEVICE DATA (30.2.11)
(12) COMMAND ASSIGNED TO SUPPLIER (30.2.12)
(13) RETURN BORESIGHT (30.2.13)
(14) RETURN EXPANDED STATUS (30.2.14)
(15) RETURN SURVEY QUALITY (30.2.15)

c. Those commands that don't transfer any data but cause a mode or operation change in the DRU. A detailed description of these commands is found in Appendix C. These commands are:

(1) OVERRIDE ALERT (30.3.1)
(2) RESET DISTANCE (30.3.2)
(3) RESTART (30.3.3)
(4) INHIBIT AUXILIARY BUS CONTROL (30.3.6)
(5) ENABLE AUXILIARY BUS CONTROL (30.3.7)
(6) STORED HEADING ALIGN (30.3.8)
(7) REALIGN (30.3.9)
(8) SHUTDOWN (30.3.10)
(9) OUT OF TRAVEL LOCK (30.3.11)
(10) INHIBIT ZERO-VELOCITY UPDATES (30.3.12)
(11) ENABLE ZERO-VELOCITY UPDATES (30.3.13)
(12) IN TRAVEL LOCK (30.3.14)
(13) ZUPT MODE REQUEST (30.3.15)
(14) ODOMETER MODE REQUEST (30.3.16)
(15) FIX ALTITUDE (30.3.17)
(16) RELEASE ALTITUDE (30.3.18)

3.5.4.4.3.3 Data message definition. Identifier Code 12 is assigned to the message associated with the Supplier Assigned Command Code 6. Detailed descriptions of all data messages transferred from the DRU are found in Appendix D. The messages are:

(1) DRU RATE DATA (30.4.1)
(2) CONFIGURATION DATA (30.4.2)
(3) NAVIGATION DATA (30.4.3)
(4) ATTITUDE DATA (30.4.4)
(5) ALIGN TIME TO GO DATA (30.4.5)
(6) ALERT DATA (30.4.6)
(7) BUILT-IN-TEST (BIT) DATA (30.4.7)
(8) TRAVEL LOCK DATA (30.4.8)
(9) POSITION DATA (30.4.9)
(10) DRU ORIENTATION AND POINTING DEVICE DATA (30.4.10)
(11) STATUS DATA (30.4.11)
(12) BORESIGHT ANGLES (30.4.12)
(13) EXPANDED STATUS DATA (30.4.13)
(14) SURVEY QUALITY (30.4.14)

3.5.4.4.3.4 Command rates and message response times. The DRU shall accept and process commands received on both data busses simultaneously at the rates and response times listed in Table IV. The two combinations of commands that are required to be processed simultaneously are: (1) 5 HZ commands received on both busses; (2) a 5 HZ command received on one bus and a 100 HZ command received on the other bus. The response times are measured beginning with transmission of the first bit of the command by the prime system and ending with receipt of the last bit of the message by the prime system. The DRU is not required to accept a new command on a particular bus until the message associated with a command previously received on that bus has been transmitted or until the required response time for the command previously received plus 10 milliseconds has elapsed with no message being sent. STATUS S2/1 shall be set within 1 second after receipt of a command that triggers any one of the following ALERTS: D2/0, D2/2, D3/5, D3/6, D3/7, D4/0, D4/1, D4/3, D4/4, D4/6, D4/7. STATUS S2/1 shall be set in the message responding to a command which triggers any of the following ALERTS: D5/0, D5/1, D5/2, D5/5, D5/6, and D5/7. A STATUS DATA message shall be sent in response to any command which triggers a D5/0 or D5/1 ALERT. A change in STATUS triggered by receipt of a command shall be reported in the message returned in response to that command for the following STATUS bits: S1/0, S1/1, S1/5, S2/2, S2/4, and S2/6.

3.5.4.4.3.5 Data bus control. Provisions shall be made to inhibit the ability of the Auxiliary Bus to enter data into the DRU or change operating modes as follows:

a Auxiliary Bus control shall be inhibited for 15 seconds after DRU turnon. STATUS bit S1/0 shall be set on both data buses.

b. Auxiliary Bus control shall automatically be enabled if no command has been received on the Main Bus within the last 2 seconds. STATUS bit S1/0 shall be reset on both data buses.

c. Auxiliary Bus control shall be enabled if the ENABLE AUXILIARY BUS CONTROL command is received on the Main Bus. STATUS bit S1/0 shall be reset on both data buses.

d. Auxiliary Bus control shall be inhibited if the INHIBIT AUXILIARY BUS CONTROL command is received on the Main Bus. STATUS bit S1/0 shall be set on both buses.

e. When Auxiliary Bus control is inhibited the Auxiliary Bus shall respond only to the following commands:

(1) RETURN TRAVEL LOCK DATA
(2) RETURN ATTITUDE DATA
(3) RETURN CONFIGURATION DATA
(4) RETURN STATUS
(5) RETURN NAVIGATION DATA
(6) RETURN ALIGN TIME TO GO DATA
(7) RETURN ALERT DATA
(8) RETURN BIT DATA
(9) RETURN DRU RATE DATA
(10) RETURN POSITION DATA
(11) RETURN DRU ORIENTATION AND POINTING DEVICE DATA
(12) RETURN BORESIGHT
(13) RETURN EXPANDED STATUS
(14) RETURN SURVEY QUALITY

If any other command is received over the Auxiliary Bus while control is inhibited, the DRU shall send a STATUS DATA message, with status bit S2/1 set, over the Auxiliary Bus. Bit 1 in character D5 of the Alert Data, described in 30.4.6, shall be set.

f. When Auxiliary Bus control is enabled the Auxiliary Bus shall respond to all commands except INHIBIT and ENABLE AUXILIARY BUS CONTROL. Should either of those commands be received, the Auxiliary Bus shall indicate an Alert in a STATUS DATA message and bit 1 of Alert Data character D5 shall be set.

3.5.4.5 Travel lock discrete. If the Configuration Definition Flag for travel lock discrete (3.5.8.8c) is set, the DRU shall use the travel lock discrete to determine whether the pointing device is in or out of travel lock. When the discrete signal to the DRU is a logic "0", the pointing device shall be considered to be in travel lock. When the discrete signal to the DRU is a logic "1", the pointing device shall be considered to be out of travel lock.

3.5.4.6 Odometer interface. The DRU shall utilize odometer pulses representing incremental distance traveled in forward and reverse directions by the vehicle on which the DRU is mounted. Both the forward and backward direction pulses are nominally scaled to represent 0.165 feet per pulse. The pulses are 800 ± 80 micro-seconds in width and the frequency of the pulses varies from 0 to 711 pulses/second for a forward or backward speed of 0 to 80 miles per hour.

The DRU shall generate discrete test commands which will direct the VMS to perform BIT.

TABLE IV. COMMAND RATES AND MESSAGE RESPONSE TIMES

COMMAND	MAXIMUM REQUEST RATE	RESPONSE MESSAGE	MAXIMUM RESPONSE TIME
ACCEPT POSITION	5/sec	STATUS DATA	130 msec
ACCEPT CONFIGURATION DATA	5/sec	STATUS DATA	130 msec
RETURN DRU RATE DATA	100/sec	DRU RATE DATA	10 msec
RETURN STATUS	5/sec	STATUS DATA	130 msec
RETURN NAVIGATION DATA	5/sec	NAVIGATION DATA	130 msec
RETURN ATTITUDE DATA	100/sec	ATTITUDE DATA	10 msec
RETURN ALIGN TIME TO GO	5/sec	ALIGN TIME TO GO DATA	130 msec
RETURN ALERT DATA	5/sec	ALERT DATA	130 msec
RETURN BIT DATA	5/sec	BIT DATA	130 msec
RETURN TRAVEL LOCK DATA	100/sec	TRAVEL LOCK DATA	10 msec
RETURN POSITION DATA	5/sec	POSITION DATA	130 msec
RETURN DRU ORIENTATION AND POINTING DEVICE DATA	100/sec	DRU ORIENTATION AND POINTING DEVICE DATA	10 msec
OVERRIDE ALERT	5/sec	STATUS DATA	130 msec
RESET DISTANCE	5/sec	STATUS DATA	130 msec
RESTART	5/sec	STATUS DATA	130 msec
ENABLE AUXILIARY BUS CONTROL	5/sec	STATUS DATA	130 msec
INHIBIT AUXILIARY BUS CONTROL	5/sec	STATUS DATA	130 msec
STORED HEADING ALIGN	5/sec	STATUS DATA	130 msec
REALIGN	5/sec	STATUS DATA	130 msec
SHUTDOWN	5/sec	STATUS DATA	130 msec
INHIBIT ZERO-VELOCITY UPDATE	5/sec	STATUS DATA	130 msec
ENABLE ZERO-VELOCITY UPDATE	5/sec	STATUS DATA	130 msec
IN TRAVEL LOCK	5/sec	STATUS DATA	130 msec
OUT OF TRAVEL LOCK	5/sec	STATUS DATA	130 msec
RETURN CONFIGURATION DATA	5/sec	CONFIGURATION DATA	130 msec
ACCEPT BORESIGHT	5/sec	STATUS DATA	130 msec
RETURN BORESIGHT	5/sec	BORESIGHT ANGLES	130 msec
FIX ALTITUDE	5/sec	EXPANDED STATUS DATA	130 msec
RELEASE ALTITUDE	5/sec	EXPANDED STATUS DATA	130 msec
RETURN EXPANDED STATUS	5/sec	EXPANDED STATUS DATA	130 msec
RETURN SURVEY QUALITY	5/sec	STATUS DATA	130 msec

The commands and correct VMS responses are as follows:

BIT Command #1	BIT Command #2	Odometer Signal (Pulses/sec) Forward	Odometer Signal (Pulses/sec) Reverse
1	0	355 ± 53	0
0	1	0	355 ± 53
1	1	0	0
0	0	Normal Operating Condition	

If the correct responses are not received during VMS BIT, bit 5 of STATUS character S2 shall be set and bit 1 of BUILT-IN-TEST DATA character D2 shall be set.

3.5.5 Travel lock. If the configuration has a pointing device (weapon, radar antenna, sensor pod, etc.), the DRU is normally mounted to the pointing device. When the pointing device is stowed for travel by physically clamping it to the vehicle chassis, it is said to be "in travel lock". When the pointing device is unclamped and elevated/rotated, it is said to be "out of travel lock".

The DRU shall provide continuous measurements of vehicle attitudes when the pointing device is in travel lock and measurements of pointing device attitudes when the pointing device is in or out of travel lock.

If either the Travel Lock Discrete or Travel Lock Commands Configuration Flag is set (3.5.8.8), the DRU shall determine whether the pointing device is in or out of travel lock by the travel lock discrete (3.5.4.5) or by the IN TRAVEL LOCK command and OUT OF TRAVEL LOCK command.

When the travel lock discrete is a logic "1" or on receipt of the OUT OF TRAVEL LOCK command, which will be issued just prior to the pointing device leaving travel lock, the DRU shall:

a. Freeze vehicle attitudes.
b. Freeze and store travel lock references (azimuth and pitch) in terms of the appropriate coordinate frame.
c. Reset bit 4 of STATUS character S2.
d. Automatically enter the ZUPT mode, set bit 3 of STATUS character S1, and do not use VMS data to aid the inertial system if the Configuration Definition Flag for Odometer/ZUPT Mode is set (3.5.8.8a).
e. If the vehicle moves, set bit 0 of ALERT DATA character D3.

When the travel lock discrete is a logic "0" or on receipt of the IN TRAVEL LOCK command, which will be issued after the pointing device is clamped to the vehicle chassis, the DRU shall:

a. Provide present vehicle attitudes.
b. Provide present pointing device azimuth and pitch for travel lock reference.
c. Set bit 4 of STATUS character S2.
d. Automatically enter the Odometer Aided mode, reset bit 3 of STATUS character S1, and use VMS data, if the Configuration Definition Flag for Odometer/ZUPT mode is set (3.5.8.8a).
e. Reset bit 0 of ALERT DATA character D3 (if it has not already been reset).

If neither the Travel Lock Discrete nor Travel Lock Commands Configuration Flag is set, the DRU shall assume the pointing device is always in travel lock.

3.5.6 Shot detect. The DRU shall detect gun firing. If the Configuration Definition Flag for shot detect (3.5.8.8e) is set, the DRU shall set bit 3 of STATUS character S2 when the DRU detects a shot. Two seconds later, the DRU shall reset bit 3 of STATUS character S2 and correct travel lock references and vehicle attitudes for vehicle rotations which have occurred during gun firing. In making the corrections, the DRU shall assume that the DRU and vehicle chassis are rigidly coupled and that the vehicle chassis does not move when the gun is out of travel lock except during gun firing.

3.5.7 Position updates. The DRU shall accept position updates while the vehicle is stationary upon receipt of an ACCEPT POSITION command on the data bus. The position data may be entered into the prime system manually or automatically from an externally referenced positioning system connected to the prime system computer. If the criteria for acceptance of data entry of input parameters have been met, the DRU shall accept updates in any of the following groupings and conditions:

When operating in the Universal Transverse Mercator Grid:

a. Hemisphere, zone, spheroid, northing, easting, and altitude either in terms of the normal zone or extended zone, but only during initialization or restart.
b. Hemisphere, zone, northing, easting, and altitude either in terms of the normal zone or extended zone.
c. Hemisphere, zone, northing, and easting either in terms of the normal zone or extended zone.
d. Altitude only.
e. Designation of normal zone or extended zone for output messages.

When operating in the British National Grid:

a. Spheroid, northing, easting, and altitude in terms of the British National Grid, but only during initialization or restart.
b. Northing, easting, and altitude in terms of the British National Grid.
c. Northing and easting in terms of the British National Grid.
d. Altitude only.

The DRU shall accept a spheroid update only during initialization or restart. The DRU shall not accept any update in a grouping if one or more update(s) in the grouping is rejected. The DRU shall not accept partial updates of horizontal position. The DRU shall accept updates in terms of the normal zone or extended zone regardless of the designation of the zone/extended zone for output messages.

When a parameter is not being updated, the input data will be set to the following specified values:

PARAMETER	VALUE
Horizontal Position	
DRU Hemisphere/Zone	0
Easting	0
Northing	16,777,215
Altitude	8,000
DRU Spheriod	15

Partial updates of horizontal position shall be rejected.

3.5.8 Configuration data. The DRU shall use configuration data to tailor its operation to the prime system requirements. This data includes alignment angles to vehicle and prime system payload being oriented (pointing device), offset distances between the DRU and prime system position reference point, and configuration definition flags.

Additional information such as nominal odometer scale factor and fuel consumption factor is provided for use as needed by a manufacturer's DRU design.

3.5.8.1 Software case boresight angles to vehicle. The DRU shall use the software case boresight angles to the vehicle, α, β, γ, as defined in 6.6.3.3.4, to calculate Vehicle Pitch, Vehicle Cant, Vehicle Roll, Vehicle Grid Azimuth, and Vehicle Geodetic Azimuth.

3.5.8.2 Software case boresight angles to pointing device. The DRU shall use the software case boresight angles to the pointing device, **A**, **B** and **Γ** , as defined in 6.6.3.3.5, to calculate Pointing Device Grid Azimuth, Pointing Device Geodetic Azimuth, Pointing Device Pitch, Pointing Device Cant, Pointing Device Pitch Rate, and Pointing Device Azimuth Rate.

3.5.8.3 Position offset distances. The DRU shall use position offset distances to transfer positions to/from a reference point on the transporting vehicle when the DRU is in travel lock. When the DRU is out of travel lock, the offset distances shall not be used and the position reference point shall be the DRU case reference frame origin (Figure 27).

The position offset distances, ΔX, ΔY, and ΔZ, are in the vehicle coordinate frame and are measured from the DRU case reference frame origin. ΔX, the offset along the vehicle longitudial axis, may have any value from -9.9 to +9.9 meters. ΔX is positive if the offset point is forward of the DRU in the direction of travel and is negative if behind. ΔY, the offset along the vehicle cross axis, may have any value from -4.9 to +4.9 meters. ΔY is positive if the offset point is to the right of the DRU, looking in the direction of forward travel, and is negative if to the left. ΔZ, the offset along the vehicle vertical axis, may have any value from -4.9 to +4.9 meters. ΔZ is positive if the offset point is above the DRU and is negative if below.

3.5.8.4 Odometer scale factor. The nominal odometer scale factor is (nominal number of VMS pulses/mile)/32000 pulses/mile). The nominal odometer scale factor will be in the range of 0.750 to 1.250.

3.5.8.5 ZUPT intervals. The DRU shall request ZUPTs at the intervals specified in configuration data for both the odometer and ZUPT modes of operation. The range for the Odometer mode shall be 2 - 63 minutes in increments of 1 minute. The range for the ZUPT mode shall be 2 - 15 minutes in increments of 0.25 minute.

3.5.8.6 Align/realign time. The DRU shall base align time to go on the appropriate align time. The DRU shall indicate completion of alignment when the appropriate alignment time has been exceeded. The range for Normal Align shall be 3.5 - 63.75 minutes, in increments of 0.25 minute. The maximum Normal Align time for meeting specified performance is 15 minutes. The ranges for Stored Heading Align and Realign are 1.0 - 7.75 minutes, in increments of 0.25 minute. The maximum Stored Heading Align time for meeting specified performance is 1.5 minutes. The maximum realign time for meeting specified performance is 3.5 minutes.

3.5.8.7 Fuel consumption factor. This factor is the change in vehicle pitch per unit distance travelled due to consumption of fuel. The units are radians per meter travelled.

3.5.8.8 Configuration definition flags. The DRU shall use configuration definition flags as follows:

a. Odometer/exclusive ZUPT mode. This Flag indicates the basic aiding mode to be used by the DRU. When set the DRU shall assume a VMS is connected and shall operate in the odometer mode (3.5.3.2.1.3). When reset the DRU shall operate in the exclusive ZUPT mode (3.5.3.2.1.2).

b. Tracked/wheeled vehicle. When set this flag indicates to the DRU that it is installed on a tracked vehicle. When reset it indicates a wheeled vehicle.

c. Travel lock discrete. When set the DRU shall use the travel lock discrete to determine if it is in or out of travel lock. When reset the DRU shall ignore the travel lock discrete.

d. Travel lock commands. When set the DRU shall use the IN TRAVEL LOCK and OUT OF TRAVEL LOCK commands to determine if it is in or out of travel lock. When reset the DRU shall not use the IN TRAVEL LOCK and OUT OF TRAVEL LOCK commands and shall set bit 6 of ALERT DATA character D5 if either command is received. When the Travel Lock Commands Flag is set, the DRU shall assume it is in travel lock at turn on. (NOTE: To prevent conflicts in determining travel lock status, the Travel Lock Discrete Flag and Travel Lock Commands Flag should not be set simultaneously.) If both the Travel Lock Discrete Flag and Travel Lock Commands Flag are reset, the DRU shall assume it is always in travel lock.

e. Shot detect. When set the DRU shall correct travel lock reference and vehicle attitudes for vehicle rotations which occur during gun firing. When reset the DRU shall not perform these corrections.

f. Boresight angles. When set the DRU shall use pointing device boresight angles entered via the ACCEPT BORESIGHT command. When reset the DRU shall use the stored pointing device boresight angles, in the selected configuration code, and shall set bit 7 of ALERT DATA character D5 if an ACCEPT BORESIGHT command is received.

g. Azimuth. When set the DRU shall output geodetic azimuth. When reset the DRU shall output grid azimuth.

h. Vehicle Cant/Roll. When set the DRU shall output vehicle roll. When reset the DRU shall output vehicle cant.

3.5.8.9 Configuration selection. The DRU shall identify the configuration data to be used by the configuration code number programmed for the four configuration discretes on J1. An open circuit shall indicate a logic "0". A connection to signal ground shall indicate a logic "1". The discrete input circuits shall require external drivers to source or sink no more than 2.0

milliamperes. The DRU shall contain 15 sets (configuration code numbers 0 through 14) of permanently stored configuration data. When configuration code 15 is selected, the DRU shall accept and use configuration data loaded using an ACCEPT CONFIGURATION DATA Command. The DRU shall maintain a Configuration Data Present Flag which indicates whether valid configuration data has been loaded for configuration code 15, with an ACCEPT CONFIGURATION DATA command. Configuration data values are listed in APPENDIX F.

3.5.8.9.1 Initializing configuration data. Upon turn on, the DRU shall determine the configuration code number from the configuration discretes on J1. For configuration codes 0 - 14 the DRU shall select and use the permanently stored configuration data applicable to the selected configuration code number. For configuration code 15 the DRU shall select and use the configuration data previously entered via an ACCEPT CONFIGURATION DATA command, if the Configuration Data Present Flag is set. If the Configuration Data Present Flag, for configuration code 15, is reset, the DRU shall: Set Alert bit D5/3; set STATUS bit S1/7; reset STATUS bits S1/4, S1/5, S2/0 and S2/2; and suspend alignment. When a valid ACCEPT CONFIGURATION DATA command is received, the DRU shall: store the configuration data in program alterable, non-volatile memory; set the Configuration Data Present Flag; override Alert D5/3; and continue alignment. The DRU shall retain and use the stored configuration data until it is changed (3.5.8.9.2) or cleared (3.5.8.10).

3.5.8.9.2 Changing configuration data. For configuration code 15 the DRU shall store and use new configuration data supplied by an ACCEPT CONFIGURATION DATA command.

3.5.8.10 Clearing temporary configuration data. The DRU shall clear all data loaded via an ACCEPT CONFIGURATION DATA command and reset the Configuration Data Present Flag when: The DRU detects a fault condition where the stored configuration data may have been altered; or the configuration code number, at turnon, differs from the configuration code number present when the DRU was last shut off.

3.5.8.11 Configuration data output. Upon receipt of a RETURN CONFIGURATION DATA command, the DRU shall return the values of configuration data presently being used via a CONFIGURATION DATA Message.

3.5.9 Pointing device boresight angles.

3.5.9.1 Pointing device boresight angle entry. If the Boresight Angles Configuration Flag is set, upon receipt of a valid ACCEPT BORESIGHT command, the DRU shall: store the received pointing device boresight angles in program alterable, non-volatile memory; set a Boresight Angles Present Flag, which indicates that boresight angles were received and stored; and use the new values. The stored boresight angles shall not be modified unless a new ACCEPT BORESIGHT command is received or they are cleared in accordance with 3.5.9.2. When the Boresight Angles Present Flag is reset, the DRU shall: set Alert bit D5/4; set STATUS bit S1/7; and reset STATUS bits S1/4, S1/5, S2/0, and S2/2. Alert bit D5/4 shall not be reset until a valid ACCEPT BORESIGHT command has been received and processed.

If the Boresight Angles Configuration Flag is reset, the DRU shall use the permanently stored values for pointing device boresight angles for the selected configuration code.

3.5.9.2 Clearing pointing device boresight angles. The DRU shall clear the temporary stored pointing device boresight angles and reset the Boresight Angles Present Flag when: the configuration code number at turnon differs from the configuration code number present when the DRU was last shut off; or the DRU detects a fault condition where the stored boresight angles may have been altered.

3.5.9.3 Output of pointing device boresight angles. Upon receipt of a RETURN BORESIGHT command, the DRU shall transmit the pointing device boresight angles presently being used in a BORESIGHT ANGLES Message.

3.5.10 British National Grid. During initialization, if an ACCEPT POSITION command is received in which the least significant 4 bits of D8 designate spheroid No. 0 (Airy), the DRU shall output coordinates and grid azimuths in the British National Grid as described in the Ordnance Survey Information Leaflet, No. 72,. The DRU shall also output pertinent messages in the British National Grid if it was doing so prior to the last shutdown and no ACCEPT POSITION command has been received that changed the spheroid. During initiation of, and while operating in the British National Grid, the DRU shall ignore characters D6 and D7 of the ACCEPT POSITION command during updates. Characters D22 of the NAVIGATION DATA message and D2 of the POSITION DATA message shall indicate a plus for the hemisphere and a zero for zone.

If the Configuration Definition Flag for Azimuth (3.5.8.8g) is reset, pointing device grid azimuths, vehicle grid azimuths, and travel lock grid azimuth references in messages shall be in terms of the British National Grid. If the Configuration Definition Flag for Azimuth is set, all azimuths in messages shall be geodetic.

3.5.11 Normal zone. If the DRU is operating in the Universal Transverse Mercator Grid, then, at anytime during a mission when character D6 of the last received ACCEPT POSITION command is ± zero or when the DRU crosses an extended zone boundary, the DRU shall output UTM coordinates and grid azimuths in the normal zone. That is, in terms of standard (normal) hemisphere and zone for the geographic position where it is located. Normal zone boundaries shall be in accordance with TM 5-241-8, Universal Transverse Mercator Grid. When the DRU crosses the equator or zone boundary, the DRU shall automatically reference the coordinates to the changed hemisphere/zone and set bit 5 of ALERT DATA character D4.

If the Configuration Definition Flag for Azimuth (3.5.8.8g) is reset, pointing device grid azimuths, vehicle grid azimuths, and travel lock grid azimuth references in messages shall be in terms of the hemisphere and zone in which the DRU is located. If the Configuration Definition Flag for Azimuth is set, all azimuths in messages shall be geodetic.

3.5.12 Extended zone. If the DRU is operating in the Universal Transverse Mercator Grid, then, at anytime during a mission when character D6 of the last received ACCEPT POSITION command designates a hemisphere and zone, the DRU shall output UTM coordinates and grid azimuths in terms of the extended zone and the spheroid designation stored/input during initialization.

The designated hemisphere identifies the hemisphere whose boundary shall be extended 100km into the adjacent hemisphere, and the designated zone identifies the zone whose boundaries shall be extended 100km into each adjacent zone (6.6.1.4). Together, they define the "extended zone". For the case where the northern hemisphere is extended into the southern, a false northing of 10,000,000 shall be added to the (negative) northing value to obtain the output value for messages, and the zone sign shall be positive to indicate that the output is a northern hemisphere extension. For the case where the southern hemisphere is extended into the northern, the output shall be the northern hemisphere value, and the zone sign shall be negative to indicate that the output is a southern hemisphere extension. When the DRU crosses an extended zone boundary, the DRU shall automatically reference UTM coordinates and grid azimuths in terms of the normal hemisphere and normal zone in which it is located and set bit 5 of ALERT DATA character D4.

If the Configuration Definition Flag for Azimuth (3.5.8.8g) is reset, pointing device grid azimuths, vehicle grid azimuths, and travel lock grid azimuth references in messages shall be in terms of the extended zone. If the Configuration Definition Flag for Azimuth is set, all azimuths in messages shall be geodetic.

3.6 Performance.

3.6.1 General. Unless otherwise specified, values set forth to establish the requirements for performance apply to performance under any and all combinations of conditions and environments as specified herein.

3.6.1.1 Accuracy. Coordinate and reference frame transformation computations shall introduce no more than 0.1 meter position error and 0.01 mil orientation error. Accuracies specified herein shall be met with commanded Realign performed no more than once per 2 hours.

Azimuth, Pitch, Roll, and Angular Rate accuracy requirements stated herein shall be met at any specified temperatures. Azimuth accuracy requirements stated herein shall be met with the DRU coordinate axis, $\bar{X}_C$, at any heading. Pitch and Roll accuracy requirements stated herein shall be met at any DRU case orientation.

Azimuth accuracies specified in 3.6.1.1.5.1 and 3.6.1.1.5.2 shall be met with the DRU coordinate axis, $\bar{Z}_C$, approximately vertical (+ 10°) during Normal Align and Realign and when operating at any latitude within the range of 65° south to 65° north. When operating in latitude ranges of 65° to 75° south or north, azimuth accuracies shall degrade no more than a factor of 0.42262 secant latitude.

Position accuracies stated herein shall be met at any specified temperatures. The position accuracy requirements specified herein apply when the DRU is operated as specified in 3.5.3.1.2 and when the following conditions are applicable:

a. A position update is performed after Normal Align was completed at more than one vehicle stop.
b. A position update is performed after Normal Align was completed when travel time between vehicle stops exceeded four minutes.

Position accuracies stated in 3.6.1.1.1 and 3.6.1.1.2 shall be met when operating at any latitude within the range of 75° north and with the DRU coordinate azis, $\bar{Z}_C$, approximately vertical during Normal Align and Realign.

The following is a summary of accuracy requirements.

SUMMARY OF ACCURACY REQUIREMENTS

PARAMETER	LATITUDE 65°S-65°N	LATITUDE 65°S-75°S & 65°N-75°N
Normal Align	0.67 M PE	0.283 Sec (Lat) M PE
Realign	0.67 M PE	0.283 Sec (Lat) M PE
Survey Azimuth (Time since Normal Align or Realign 2 hrs.)	0.97 M PE	0.283 Sec (Lat) +0.3 M PE
Stored Heading Align	0.1 M RMS Relative to Stored Heading	
Pitch	0.34 M PE	
Roll/Cant	0.34 M PE	
Horizontal Position Odometer Mode	10 m CEP DIST $\leq$ 4 Km 0.0025 DIST CEP DIST $>$ 4 Km	
Altitude Odometer Mode	6.7 m PE DIST $\leq$ 10 Km 0.00067 DIST PE DIST $>$ 10 Km	
Horizontal Position Exclusive ZUPT Mode/Other	18m CEP DIST $\leq$ 27 Km	18m CEP DIST $\leq$ 63.9 Cos (Lat) Km
Altitude Exclusive ZUPT Mode/Other	10 m PE DIST $\leq$ 35 Km	

3.6.1.1.1 Horizontal position, odometer mode. Horizontal position error shall not exceed 10.0 meters Circular Error Probable (CEP) for total odometer distance traveled in the range of 0 to 4,000 meters from the last position update point. Within that distance range no more than 1.0 percent of the radial errors may exceed 26.0 meters.

Horizontal position error shall not exceed 0.25 percent of the total odometer distance traveled, CEP, for distances traveled exceeding 4,000 meters from the last position update point. For distances exceeding 4,000 meters, no more than 1.0 percent of the radial errors may exceed 0.65 percent of the odometer distance traveled.

3.6.1.1.2. Altitude, odometer mode. Altitude error shall not exceed 6.7 meters Probable Error (PE) for total odometer distance traveled in the range of 0 to 10,000 meters from the last altitude update point. Within that distance range no more than 1.0 percent of the absolute values of altitude errors may exceed 26.0 meters.

Altitude error shall not exceed 0.067 percent of the total odometer distance traveled, PE for distances traveled exceeding 10,000 meters from the last position update point. For distances exceeding 10,000 meters, no more than 1.0 percent of the absolute values of altitude errors may exceed 0.26 percent of the total odometer distance traveled.

3.6.1.1.3 Horizontal position, exclusive ZUPT mode/other. When operating in the exclusive ZUPT mode with zero-velocity updates at 4 minute intervals, horizontal position error shall not exceed 18 meters Circular Error Probable (CEP) and no more than 1.0 percent of the radial error shall exceed 47 meters for the following conditions:

a. Distance traveled in the range of 0 to 27,000 meters from the last position update point, latitude within the range of 65° south to 65° north.

b. Distance traveled in the range of 0 to 63,900 x Cos (latitude) meters from the last position update point, latitude within the range of 65° to 75° south or north.

This requirement shall also apply when operating in the Odometer mode with zero-velocity updates at 10 minute intervals throughout a mission.

3.6.1.1.4 Altitude, exclusive ZUPT mode/other. When operating in the exclusive ZUPT mode, with zero-velocity updates at 4 minute intervals, altitude error shall not exceed 10 meters PE and no more than 1.0 percent of the absolute values of altitude errors shall exceed 39 meters.

The specification applies when distance traveled is in the range of 0 to 27,000 meters from the last position update point and latitude is within the range of 75° south to 75° north.

This requirement shall also apply when operating in the Odometer mode with zero-velocity updates at 10 minute intervals throughout a mission.

3.6.1.1.5 Azimuth.

3.6.1.1.5.1 Normal Align. Upon completion of Normal Align from a cold start, the DRU/Pointing Device Grid or Geodetic Azimuth error shall not exceed 0.67 mil PE. No more than 1.0 percent of the absolute values of DRU Grid or Geodetic Azimuth errors shall exceed 2.6 mils.

3.6.1.1.5.2 Realign. The accuracy requirements are the same as for Normal Align if Normal Align was used at initialization and all scheduled zero-velocity updates and prior Realigns were completed.

3.6.1.1.5.3 Stored Heading Align. Upon completion of a Stored Heading Align, the DRU/Pointing Device Grid or Geodetic Azimuth error with respect to stored heading shall not exceed 0.1 mil RMS.

3.6.1.1.5.4 Azimuth accuracy during survey. After completing a Normal Align or a Realign and traveling 2 hours in the Odometer mode with only one zero-velocity update and no commanded Realigns, the DRU/Pointing Device Grid or Geodetic Azimuth error shall not exceed 0.97 mil PE. No more than 1.0 percent of the absolute value of DRU/Pointing Device Grid or Geodetic Azimuth errors shall exceed 2.52 mils.

The specification in 3.6.1.1.5.4 shall also apply when traveling 2 hours in the ZUPT mode with zero-velocity updates at 4 minute intervals and no commanded Realigns.

3.6.1.1.6 Pitch. After completing Normal Align or after completing Stored Heading Align and thereafter throughout the mission, the DRU Pitch error and Pointing Device Pitch error shall not exceed 0.34 mil PE. No more than 1.0 percent of the absolute value of DRU Pitch errors or Pointing Device Pitch errors shall exceed 1.3 mils.

3.6.1.1.7 Roll/cant. After completing Normal Align or after completing Stored Heading Align and thereafter throughout the mission, the DRU Roll error and Pointing Device Cant error shall not exceed 0.34 mil PE. No more than 1.0 percent of the absolute value of DRU Roll errors or Pointing Device Cant errors shall exceed 1.3 mils.

3.6.1.1.8 Angular rates. After completing Normal Align or Stored Heading Align and thereafter throughout the mission, DRU and pointing device Grid or Geodetic Azimuth rate errors and Pitch and Roll rate errors shall not exceed 0.5 mil per second RMS for rates in the range of -356 to +356 mils per second. Nonlinearity shall not exceed 1 percent.

Within the angular rate ranges of -3276.8 to -356 and +356 to +3276.8 mils per second, the error shall not exceed 2.5 percent of the instantaneous rate RMS.

3.6.1.1.9 Time epoch. The reference time epoch for accuracy comparison shall be 1 millisecond prior to transmission initiation of the message furnishing the data.

3.6.1.2 Reaction time.

3.6.1.2.1 Initial alignment. In the Normal Align mode, the DRU shall be ready to survey within 15 minutes, after application of power, when operated in the ambient temperature range of -50°F (-46°C) to +140°F (+60°C) and the vehicle is stationary for the entire period. Initial alignment reaction time includes the total time needed to energize, achieve thermal control, initialize position coordinates, align to level and North, perform initial BIT, and otherwise prepare the DRU for the survey mission. If Normal Align is interrupted, reaction time may increase in accordance with 3.5.3.1.2.

3.6.1.2.2 Realign. When the DRU is operating in the survey mode, Realign shall be completed 3.5 minutes after receipt of the REALIGN command. Realign time includes the total time to restore azimuth and level alignment accuracy and return the DRU to the survey mode.

3.6.1.2.3 Stored Heading Align. Stored Heading Align shall be completed 90 seconds after receipt of the STORED HEADING ALIGN command.

3.6.1.3 Mission length and duration. DRU survey missions may range from 0 to 100 Km in length and a few minutes to 24 hours in duration. System errors shall be sufficiently controlled to maintain the accuracies specified in 3.6.1.1 when the DRU is operated during missions within the above ranges. Position updates at intervals specified in 3.6.1.1.3 and 3.6.1.1.4 are permitted to maintain accuracies in the exclusive ZUPT/other mode.

3.6.1.4 Alignment conditions.

3.6.1.4.1 Off level. The DRU shall perform as specified herein when mounted with its mounting surface nominally vertical and pitch and roll attitudes off level within the range of -10 to +10 degrees during Normal Align or Realign.

3.6.1.4.2 Base motion. The DRU shall perform as specified herein when the prime system vehicle, while nominally stationary, is subject to wind buffeting, normal crew movement, engine vibration, vibration from 60 Hz and 400 Hz engine/generator sets, and other sources of motion usually found on the battlefield.

3.6.1.5 Survey conditions.

3.6.1.5.1 Vehicle dynamics. The DRU shall perform as specified herein when operated within the following vehicle dynamic envelopes:

a. In ground vehicles, horizontal velocity within the range of 0 to 80 miles per hour. While being transported by helicopter, ground speed within the range of 0 to 150 knots.

b. In ground vehicles, vertical velocity within the range of 0 to 15 miles per hour up or down. While being transported by helicopter, vertical speed within the range of 0 to 2400 ft/min.

c. Acceleration (excluding shock and vibration) within the range of 0 to 1.5g (not including gravitational acceleration) in any direction due to vehicle starting stopping and turning.

d. Vehicle pitch within the range of -40 to +40 degrees. Vehicle cant/roll within the range of -40 to +40 degrees. The relationships of vehicle pitch and cant/roll axes to DRU case coordinates may vary from installation to installation.

e. Angular velocities within the range of 0 to 200 degrees per second around any axis.

f. Angular accelerations within the range of 0 to 6000 degrees per $(\text{second})^2$ around any axis.

g. Shock and vibration generated by the transporting vehicle, which may be a tracked vehicle, wheeled vehicle, wheeled trailer, helicopter, or helicopter lift of a palletized system. The DRU will be in the ZUPT mode when transported.

h. Drop shock sustained when helicopter lifted pallet is set down on the ground (See 3.7.10.2).

3.6.1.5.2 Deployment. In addition to operating when subjected to the above vehicle dynamics, the DRU shall perform as specified herein when operated under the following conditions:

a. Shock and vibration generated by weapon firing.

b. Rotation and elevation of a pointing device. When mounted to a pointing device, the DRU may be elevated through an angle of 105 degrees or rotated 360 degrees in azimuth when the pointing device is erected.

3.6.2 Mechanical characteristics.

3.6.2.1 Mechanical envelope. The envelope of the DRU, excluding connectors, shall be in accordance with Figures 6 through 10 inclusive. Dimensions shall be maintained as specified. BIT indicators, DS1 and DS2, and the elapsed time meter, M1, shall be located as shown, and shall be covered to prevent access except during troubleshooting and maintenance actions. Handles shall be provided for lifting the DRU and shall be located as shown.

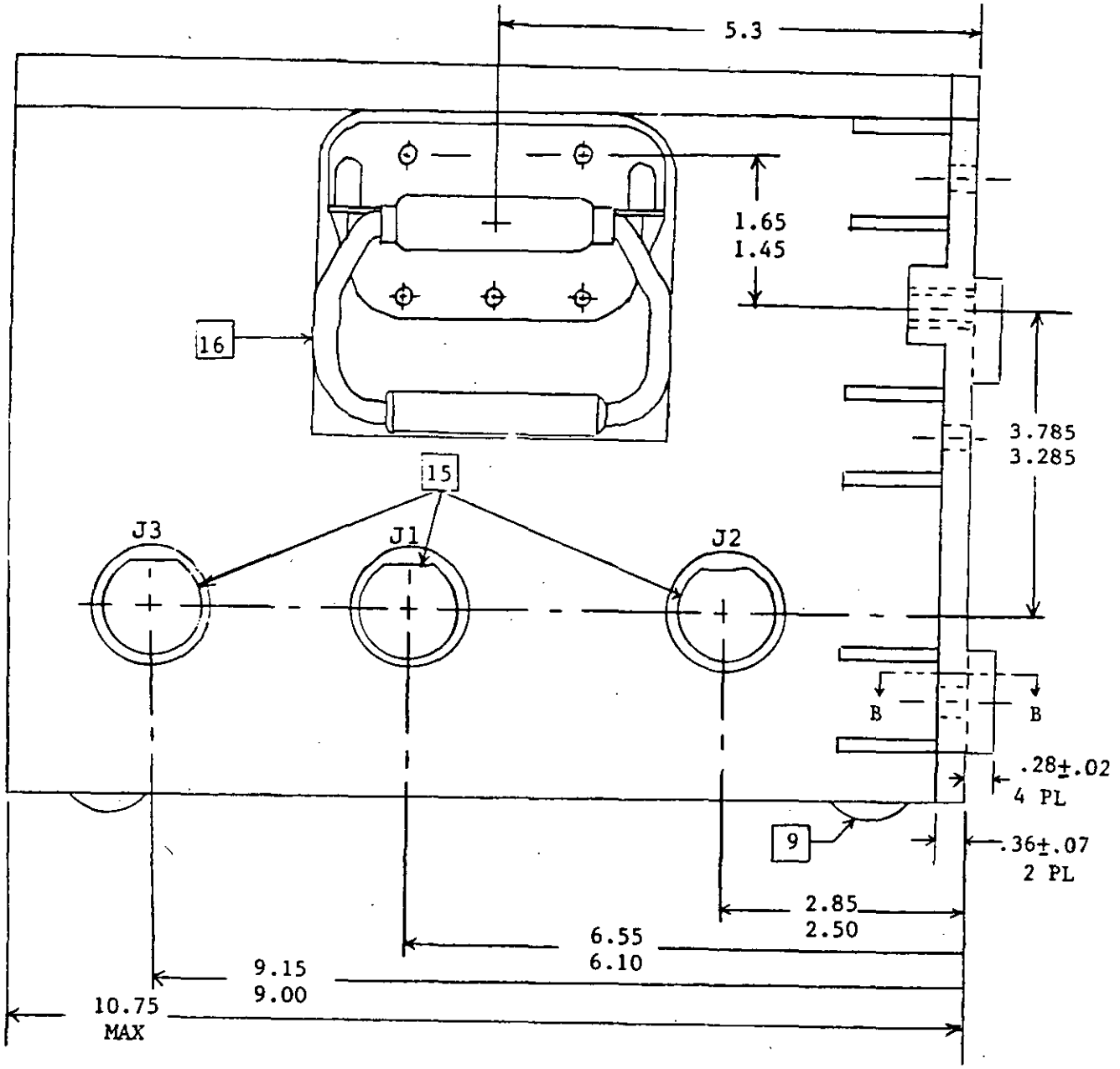


FIGURE 6 .: DRU RIGHT SIDE

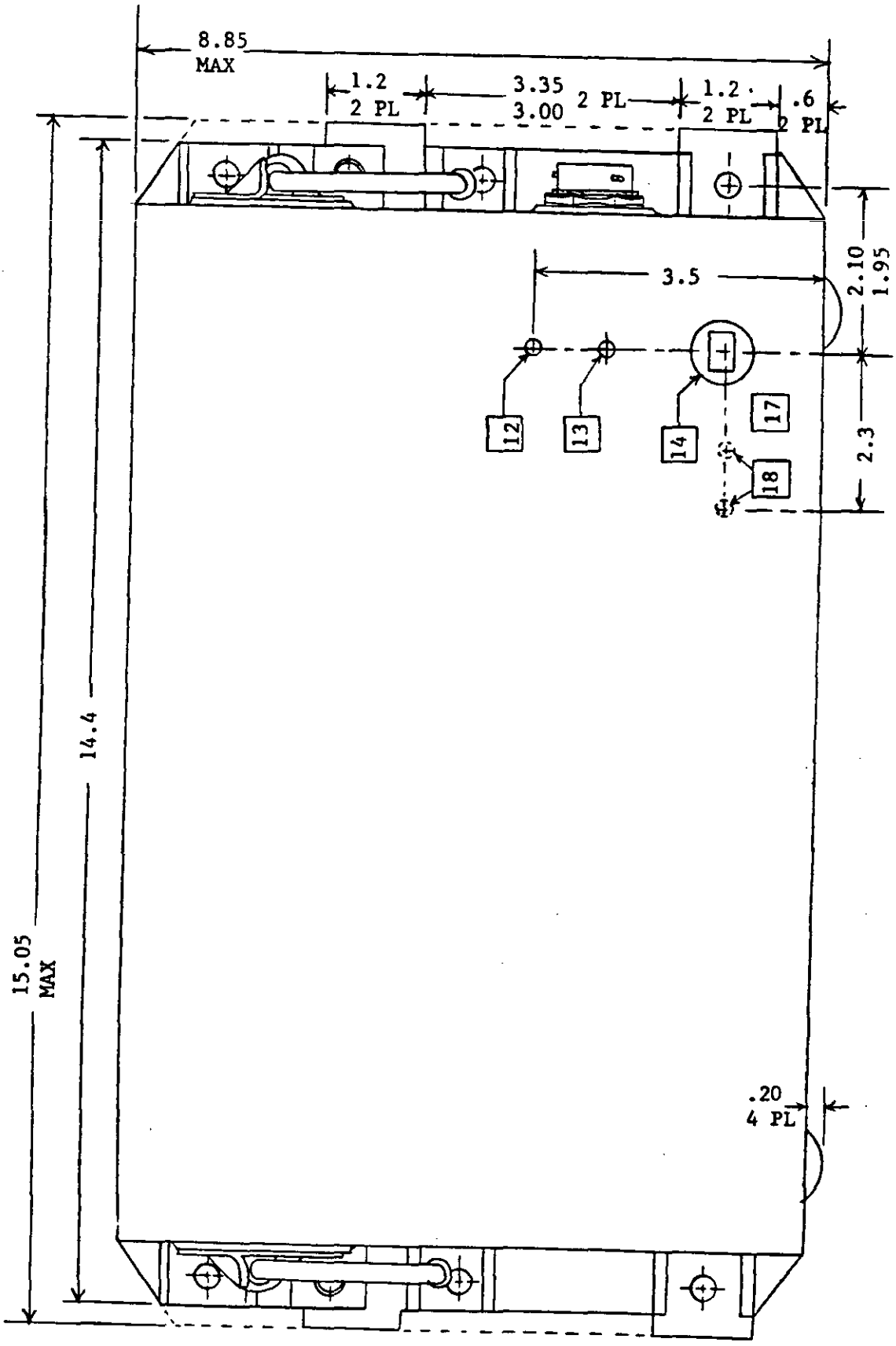


FIGURE 7 : DRU FRONT

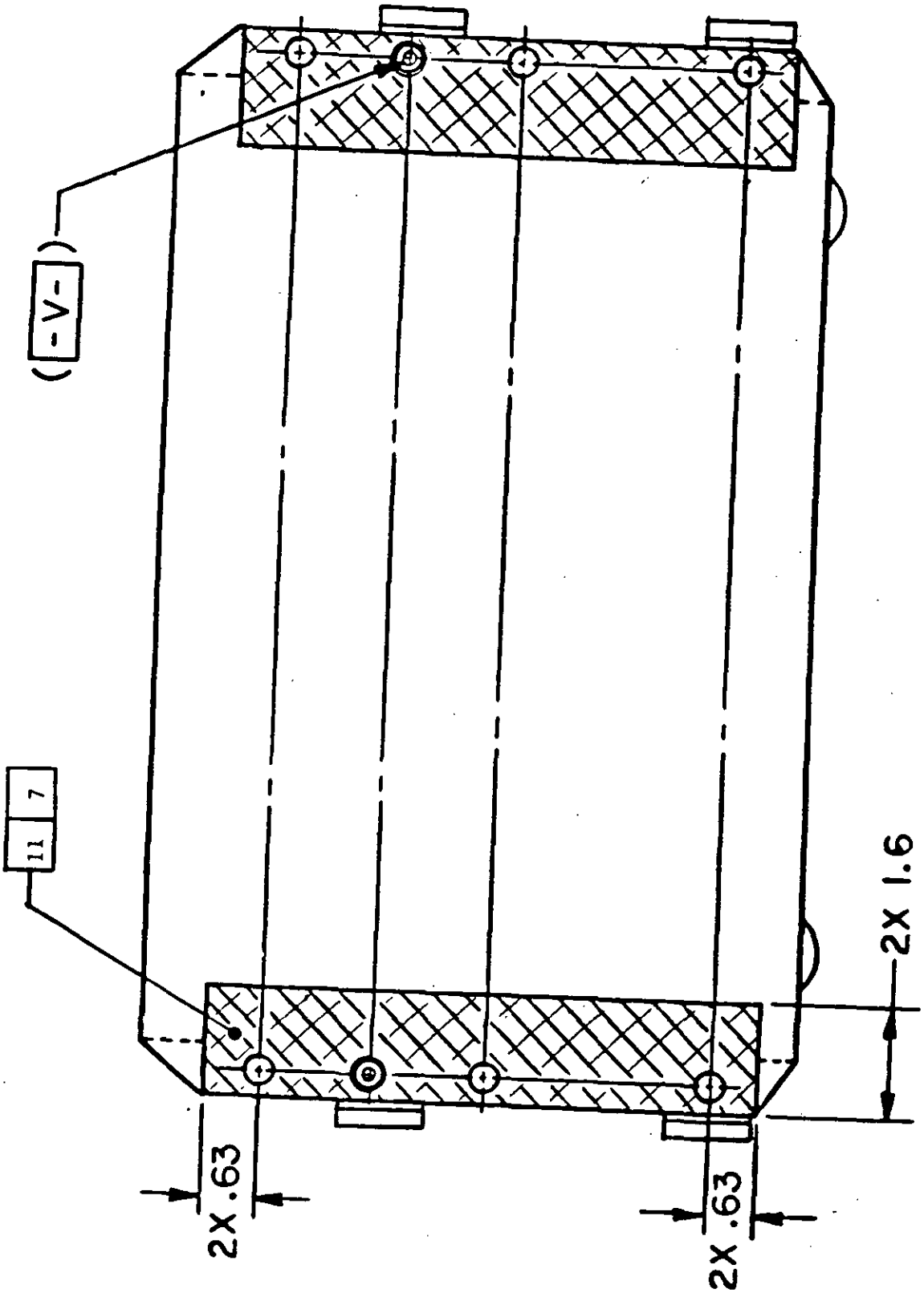


FIGURE 8 : DRU-BACK/MOUNTING SURFACE

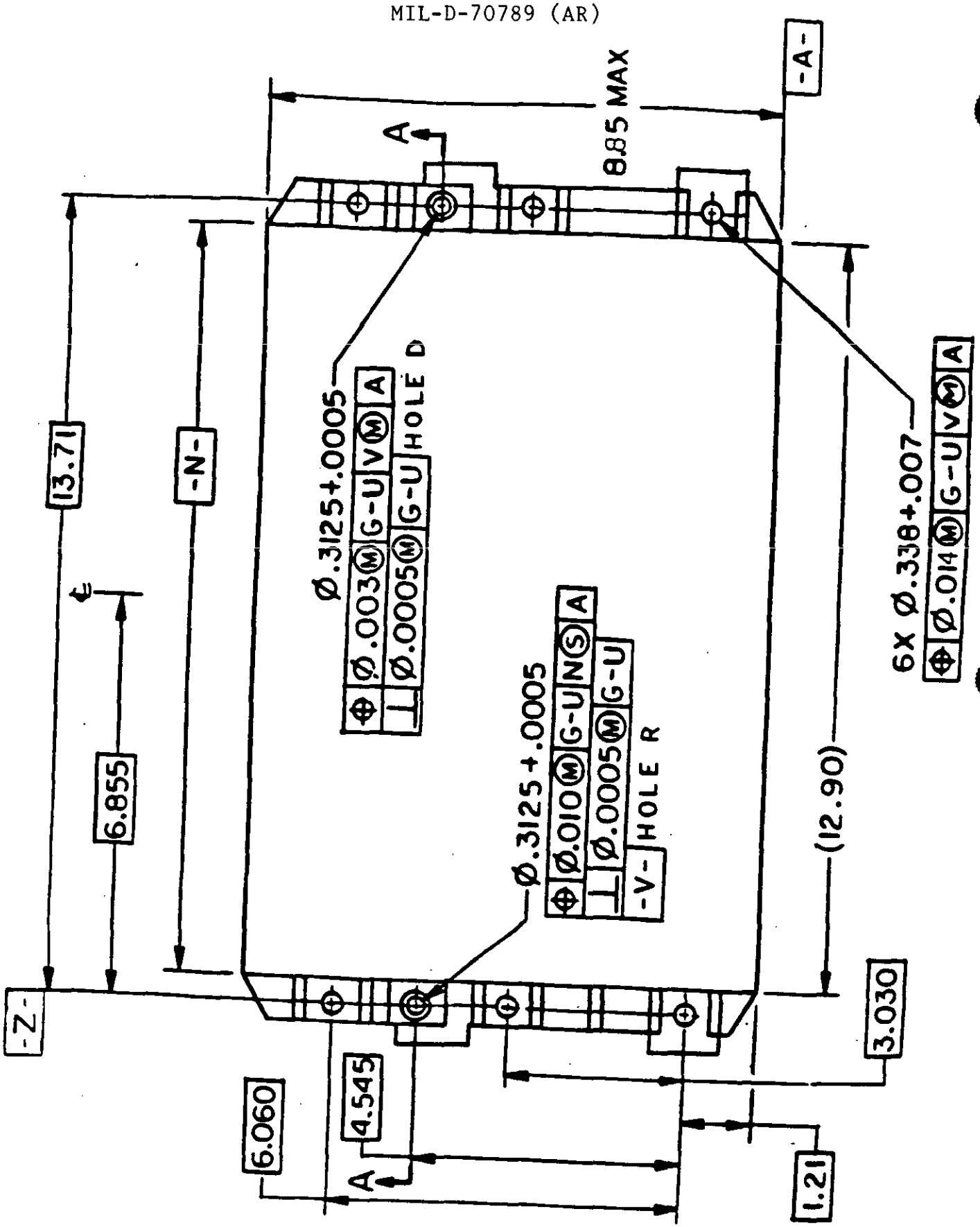
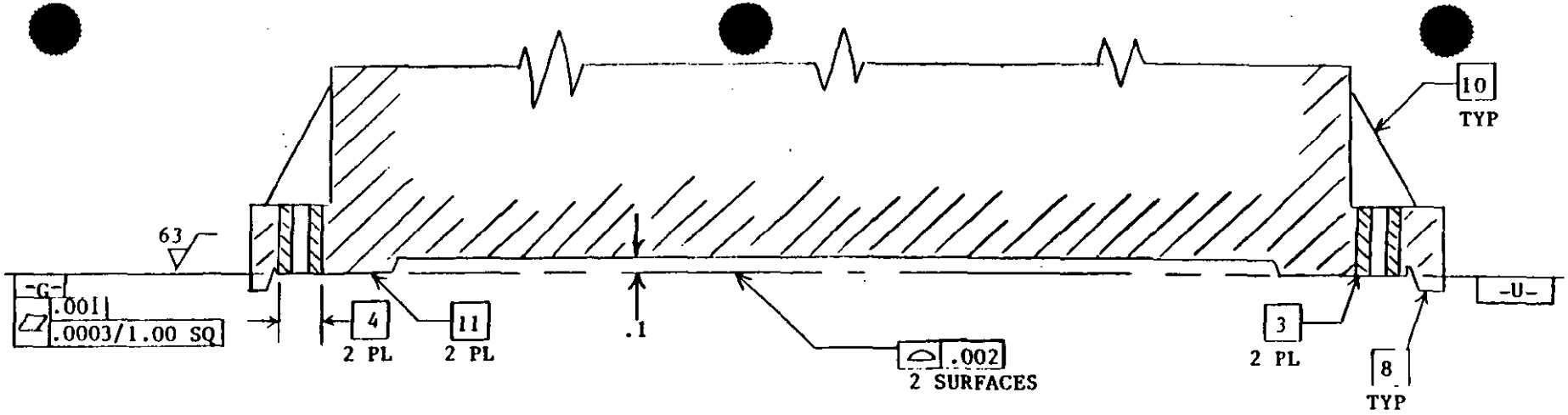


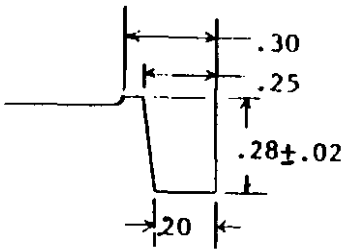
FIGURE 9 : HOLE LOCATIONS



SECTION A-A

NOTES:

1. Dimensioning and tolerancing per ANSI Y14.5M 1982.
2. Material:coefficient of expansion compatible with AL alloy 6061-T651/QQ-A-250/11.
3. Shrink fit insert: cres type 17-4PH cond A/AMS 5643; heat treat to H1025/MIL-H-6875; passivate per MIL-S-5002.
4. Fit: .4975-.4978 DIA hole, .4983-.4980 DIA insert.
5. Dimensions are in inches.
6. Unless otherwise specified, tolerances on .X±.1, .XX±.01, .XXX±.005.
7. XXXXXX Indicates precise mounting surface.
8. Protective ridges shall not interfere with mounting. Visual access required to verify proper mating of DRU and mount.
9. Shape of feet optional, height as specified. Feet shall be made of low wear material.
10. Gussets size and location optional, but shall not interfere with mating connectors and mounting bolts.
11. Mounting surface shall be free of paint for electrical bonding.
12. Bit indicator DS-1, green display, shall be labeled "PWR".
13. Bit indicator DS-2, green display, shall be labeled "DRU".
14. Elapsed time indicator, digital, shall be labeled "HOURS".
15. Connectors J1,J2,J3 to be installed with key location as shown in figure 3.6.A.
16. Handle to conform to MS-18012, without rubber coating.
17. Cover for DS-1, DS-2, and ETI not shown for clarity.
18. Alternate location for DS-1, DS-2, providing they are clearly labeled. See notes 12 and 13.



SECTION B-B TYPICAL 4PL

FIGURE 10 : SECTION A-A, SECTION B-B, NOTES

3.6.2.2 Mounting. The DRU mounting provisions and reference datums shall be in accordance with Figures 8 and 9.

3.6.2.3 Weight. The weight of the DRU shall not exceed 55 pounds.

3.6.3 Reliability. The DRU shall have a Mean-Time-Between-Failure (MTBF) of 4000 hours or greater.

3.6.4 Maintainability. The DRU shall be designed in accordance with the requirements contained herein to achieve ease and economy of maintenance.

3.6.4.1 Corrective maintenance. The DRU shall, upon occurrence of a single malfunction, be restored to operation, by replacement, within a meantime-to-repair (MTTR) of 30 minutes at the organizational level. Times include fault isolation, removal, and replacement, but do not include supply and administration time.

3.6.4.2 Preventive maintenance. The DRU shall not require any preventative maintenance other than cleaning of exterior surfaces to remove dust, dirt, and other foreign particles.

3.6.4.3 Adjustments/calibration. The DRU shall not require any adjustments or calibrations in the field that require operator interaction, nor shall the DRU require zero-velocity updates more frequently than stated herein.

3.7 Environmental service conditions. Except as otherwise noted, the DRU shall operate under any combination of the environmental conditions specified below.

3.7.1 Temperature.

3.7.1.1 Operational. The DRU shall operate in ambient air and on a mounting surface with temperatures within the range of +140°F (+60°C) to -50°F (-46°C).

3.7.1.2 Temperature shock. The DRU shall not be damaged nor rendered inoperable when subjected to abrupt temperature changes from -60°F (-51°C) to +160°F (+71°C).

3.7.1.3 Storage and transportation. The DRU shall withstand storage and transportation temperatures from +160°F (+71°C) to -60°F (-51°C) without any deterioration or adverse effects which may cause failure when the DRU is restored to operation.

3.7.1.4 Environmental Stress Screening (ESS) - temperature. Each sequence shall include a minimum of 10 temperature cycles with the last three cycles failure free. Temperature Cycling shall be performed as shown in Figure 11. Alignments shall be performed with the DRU reference frames, $\overline{X}_C$ and $\overline{Y}_C$ (Figure 27), approximately level. Azimuth, pitch and roll data at the conclusion of alignments shall be recorded. Position data during the survey mode shall be recorded every 5 minutes.

3.7.2 Altitude. The DRU shall operate at altitudes from -1300 to +10,000 feet. Non-operating, the DRU shall withstand exposure to altitudes from -1300 to +40,000 ft.

3.7.3 Humidity. The DRU shall not be damaged by operation, transportation, or storage in environments with ambient relative humidity within the range of 1 to 100 percent.

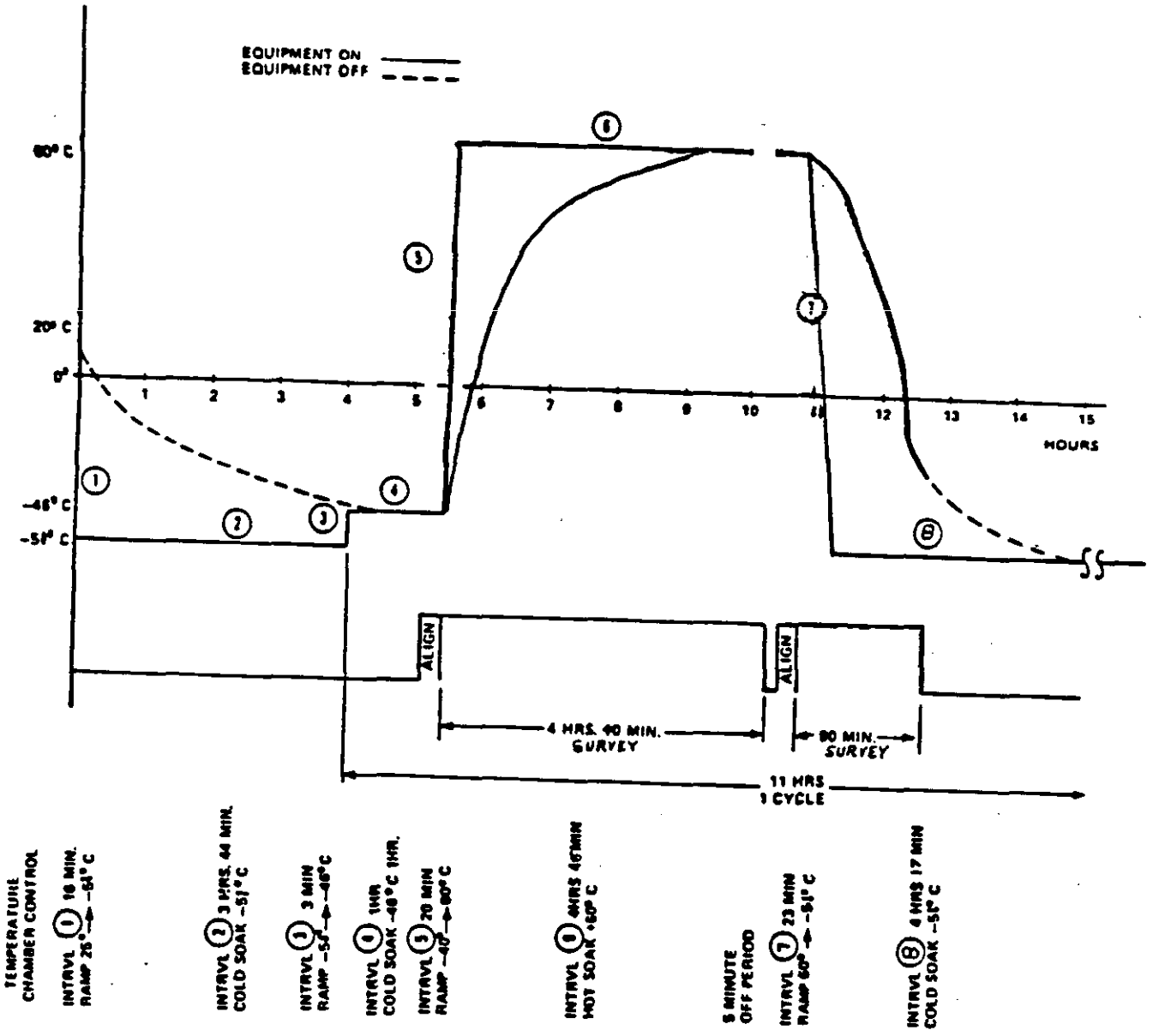
3.7.4 Snow.

3.7.4.1 Falling snow. The DRU shall not be damaged and shall operate during and after exposure to falling snow with a rate of 3 inches per hour (76 mm/hr) and crystal size of 2.0×10^{-3} inch (0.05 mm) to 0.8 inch (20 mm) in diameter.

3.7.4.2 Blowing snow. The DRU shall not be damaged and shall operate during and after exposure to blowing snow with crystal size 8.0×10^{-3} inch (0.2 mm) to 1.6×10^{-2} inch (0.4 mm) diameter and winds of at least 16 fps (5mps).

3.7.4.3 Snowload. The DRU shall not be damaged and shall be operable after exposure to a snowload of 20 lbs/ft^2 (97.7 Kg/m^2).

3.7.5 Icing.



NOTE: Align times are 15 minutes. The First align occurs after the 1 hour cold soak and is performed at -46° C. The Second align occurs after the 5 minute off period and is performed at 60° C.

FIGURE 11 Temperature Cycling

3.7.5.1 Frost. The DRU shall not be damaged and shall operate during and after exposure to frost of thickness 3 inches (76 mm) and specific gravity of 0.2.

3.7.5.2 Rime. The DRU shall not be damaged and shall operate during and after exposure to rime ice of thickness 6 inches (152 mm) and specific gravity of 0.2.

3.7.5.3 Clear glaze. The DRU shall not be damaged and shall operate during and after exposure to clear glaze ice of thickness 3 inches (76 mm) and specific gravity of 0.9.

3.7.6 Solar radiation. The DRU shall operate during and after exposure to solar radiation of 360 BTU/ft^2/hr (1135 watts/m^2) for 4 hours at an ambient temperature of +125°F (+51.6°C) at winds of 8.5 feet/sec (2.6 m/sec) or less. Maximum solar radiation will be higher by 4 BTU/ft^2/hr per 1,000 feet (43 w/m^2 per 1,000 m) and ambient air temperatures will be lower by 5°F per 1,000 feet for ground elevations above 3,000 feet up to 15,000 feet.

3.7.7 Washdown. The DRU shall suffer no damage or leakage when exposed to high pressure water washdown.

3.7.8 Salt Fog. The DRU shall not be damaged and shall operate without degradation to specified performance levels while being subjected to salt fallout of 5.7x10^{-4} pounds/feet^2/year (2.8x10^{-3} Kg/meter^2/year).

3.7.9 Fungus. The DRU shall not be damaged and shall operate after exposure for 90 days to the fungi of MIL-STD-810, Method 508.3.

3.7.10 Shock.

3.7.10.1 Operational (Gunfire). The DRU shall not be damaged and shall operate during and after repeated gun firing shock in the M109 Self Propelled Howitzer as described in the two TECOM Reports No. 86-LR(V)-41, Firing Test of M109E4 Howitzer, respectively. The DRU is trunnion mounted in the M109 application. Inquiries concerning the M109 mounting details should be directed to the procuring activity. Figures 12 through 14 were extracted from the referenced reports and provide an example of the shock spectra for the highest level charge (M203) fired in the M109.

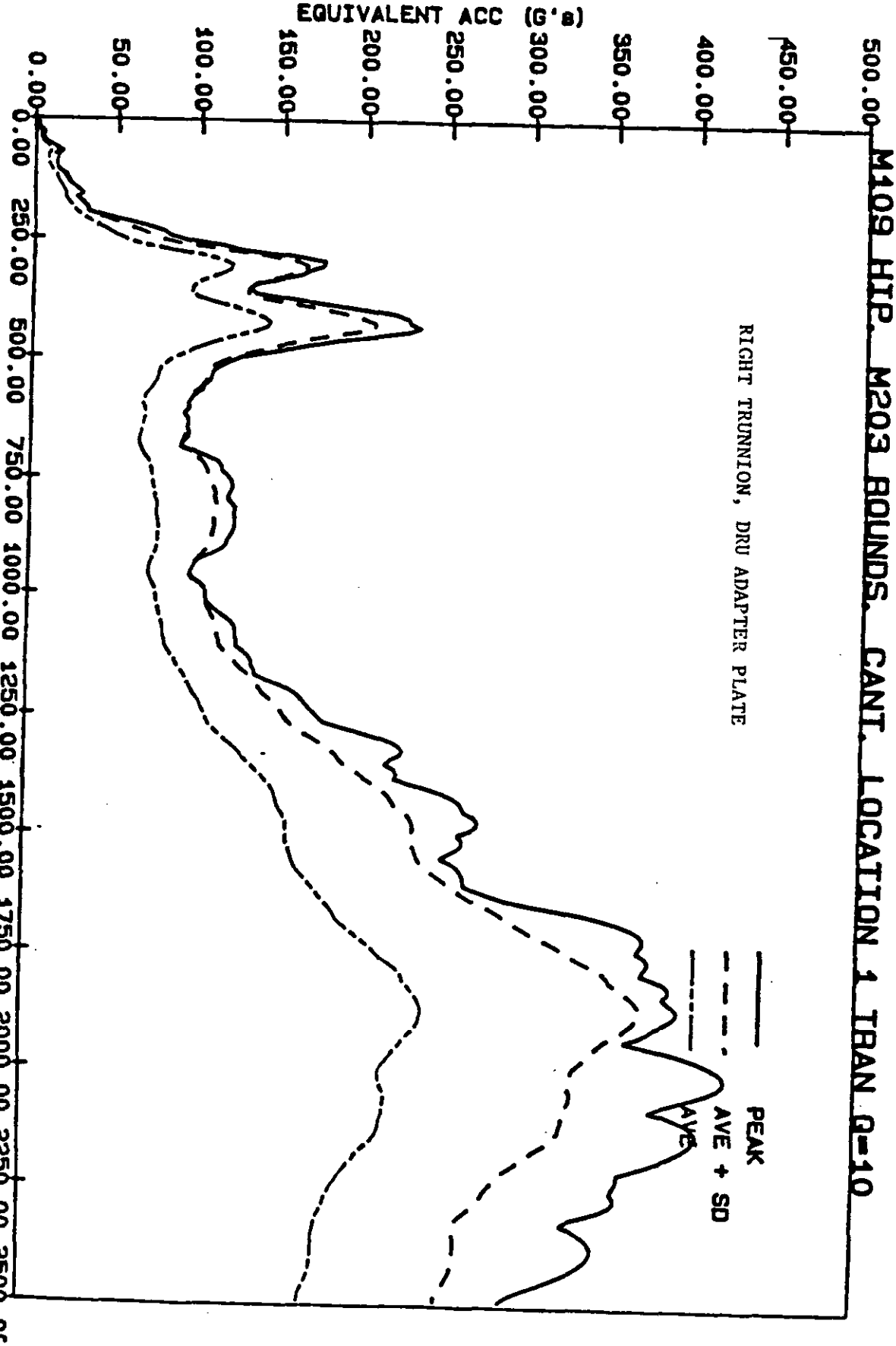


FIGURE 12 Typical Firing Shock Composite Spectrum - Lateral Axis

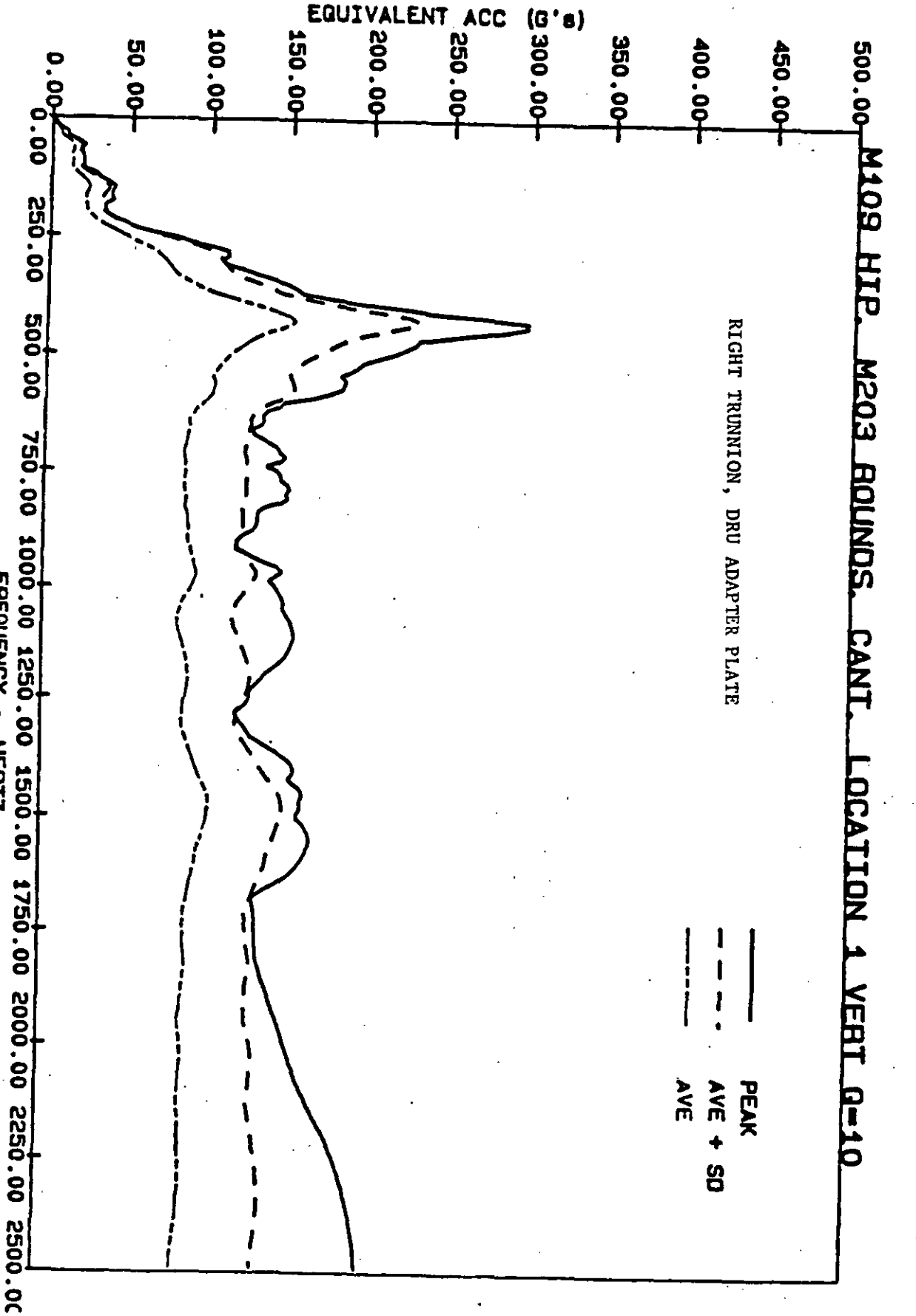


FIGURE 13 Typical Firing Shock Composite Spectrum - Vertical Axis

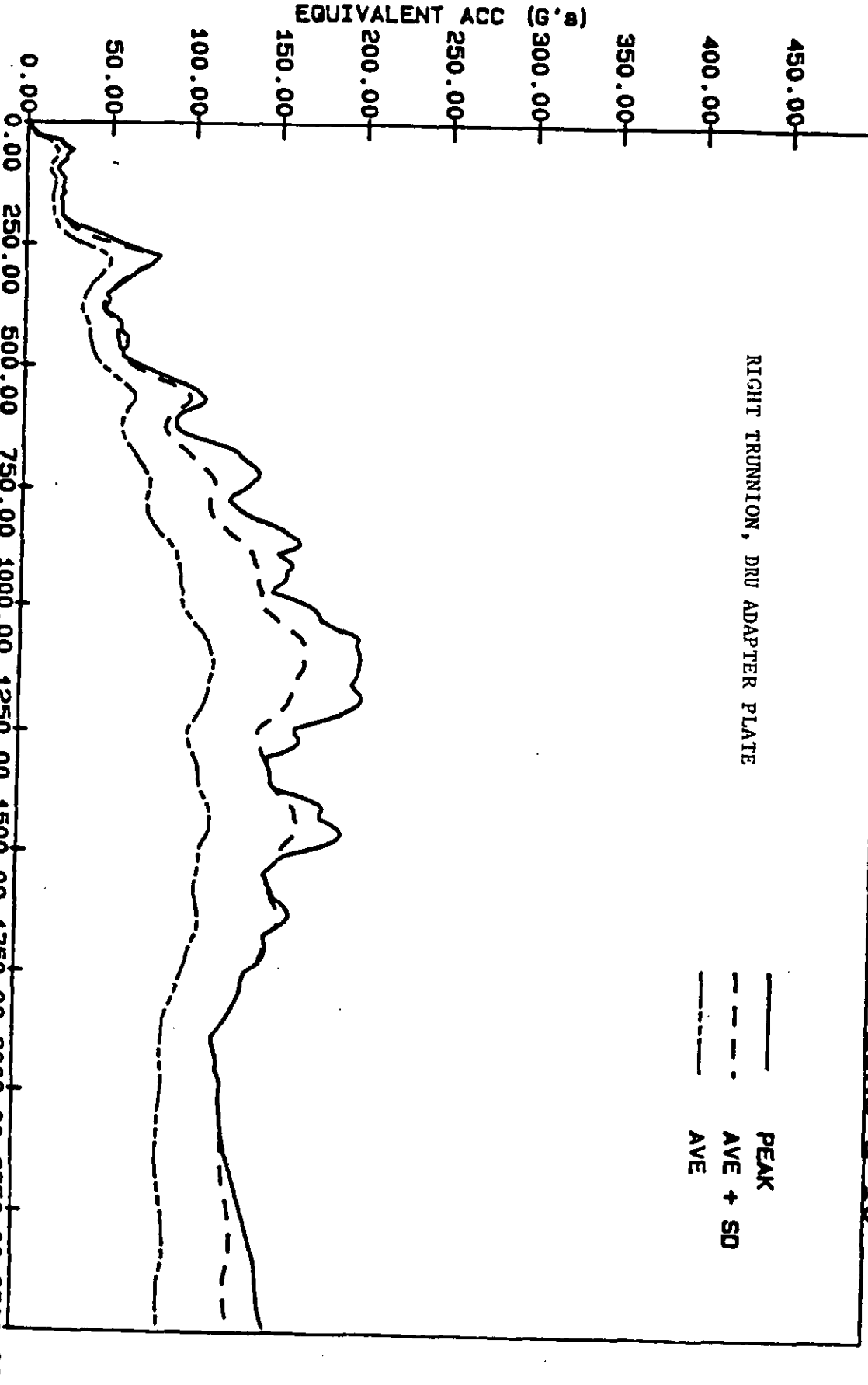


FIGURE 14 Typical Firing Shock Composite Spectrum - Longitudinal Axis

3.7.10.2 Transportation. The DRU shall not be damaged and shall operate during and after shock test as specified in MIL-STD-810, Method 516.3, Procedure I, with a 40g shock pulse of 6-9 m/sec duration.

3.7.10.3 Bench handling. The DRU shall not be damaged and shall operate after being subjected to Procedure VI of Method 516.3 of MIL-STD-810.

3.7.11 Vibration. The DRU shall operate and not be damaged while being subjected to the vibration environment of the M109 Howitzer, M113 Armored Personnel Carrier, High Mobility Multi-purpose Wheeled Vehicle (HMMWV) and Commercial Utility Cargo Vehicle (CUCV) traveling over all types of roads and cross-country terrain. The vibration environment for the M109 and M113 shall be as described in TECOM Reports, No. 87-LR(V)-2, Road Shock and Vibration Test of M109E4 Howitzer, and No. 87-LR(R)-1, Road Shock and Vibration Test of MAPS Hardware in M113A1. The DRU is trunnion mounted in the M109 and side-wall mounted in the M113. Inquiries concerning the mounting details should be directed to the procuring activity. Figures 15 through 17 were extracted from the M113 Test Report and provide an example of the vibration environment on paved road at 34 miles per hour.

3.7.12 Environmental Stress Screening (ESS) - vibration. The DRU shall be subjected to random vibration at the minimum Power Spectral Density envelope shown in Figure 18 for 10 minutes in each of three orthogonal axes. The DRU shall be operating while being subjected to random vibration. At the conclusion of the last 10 minute random vibration on the third axis, the power to the DRU shall be cycled off and on and BIT performed.

3.7.13 Electromagnetic compatibility. The DRU shall meet the requirements for electromagnetic compatibility per MIL-STD-461, MIL-STD-462 and MIL-STD-463. The DRU shall meet the requirements of MIL-E-6051 for compatibility with the total system. In addition, the DRU shall experience no degradation in attitude reference under a 3 gauss magnetic field oriented vertically and in turn, horizontally.

3.7.14 Electromagnetic interference. The DRU shall meet all emission and susceptibility characteristics as established by MIL-STD-461, MIL-STD-462, and MIL-STD-463 for Class A3 equipments and subsystems. The DRU shall meet all applicable requirements for the following: CE01, CE03, CS01, CS02, CS06, RE01, RE02, RS01, RS02, and RS03. Field strengths for RS03 shall be:

Frequency Range	Average Field Strength (V/m)	Modulation*
14 KHz to 2 MHz	25	CW
2 MHz to 20 MHz	50	CW,AM
20 MHz to 100 MHz	50	CW,AM,FM
100 MHz to 500M Hz	25	CW,AM
500 MHz to 1,000 MHz	50	CW,AM
400 MHz to 1,200 MHz	50	Pulse
1,200 MHz to 18 GHz	200	Pulse

* Modulation frequencies and waveforms shall be selected for maximum potential susceptibility (i.e. instrument sending and control frequencies, clock frequencies, etc.) Parameters of fielded radars shall be considered in determing pulse modulation characteristics.

3.7.15 Electrostatic discharge. The DRU shall not be damaged and shall operate as specified herein after being charged to potential differences of up to 300,000 volts with respect to ground potential, across a capacitance of 1,000 pf, and subsequently being discharged to ground potential through a series resistance of 500 ohms. Circuit modules, repair parts, etc, shall not be damaged by electrostatic discharge generated by normal handling during maintenance.

3.7.16 Lightning. The DRU shall not be damaged and shall operate as specified herein after being subjected to close lightning strikes at distances of 10 meters or greater. The idealized current waveform generated by severe lightning strike is shown in Figure 19. The field strengths at 10 meters are:

Peak Magnetic Field	3,2000 A/m
Peak Electric Field	3 MV/m

Electric Field Spectral Density:

Frequency	Field Density
10 Hz	160V/m/Hz
100 Hz	3 V/m/Hz
1 KHz	0.5V/m/Hz
10 KHz	500V/m/Hz
40 KHz	5 KV/m/Hz

The DRU is permitted to turn off, without damage or loss of data needed to reinitialize, when exposed to close lightning strikes.

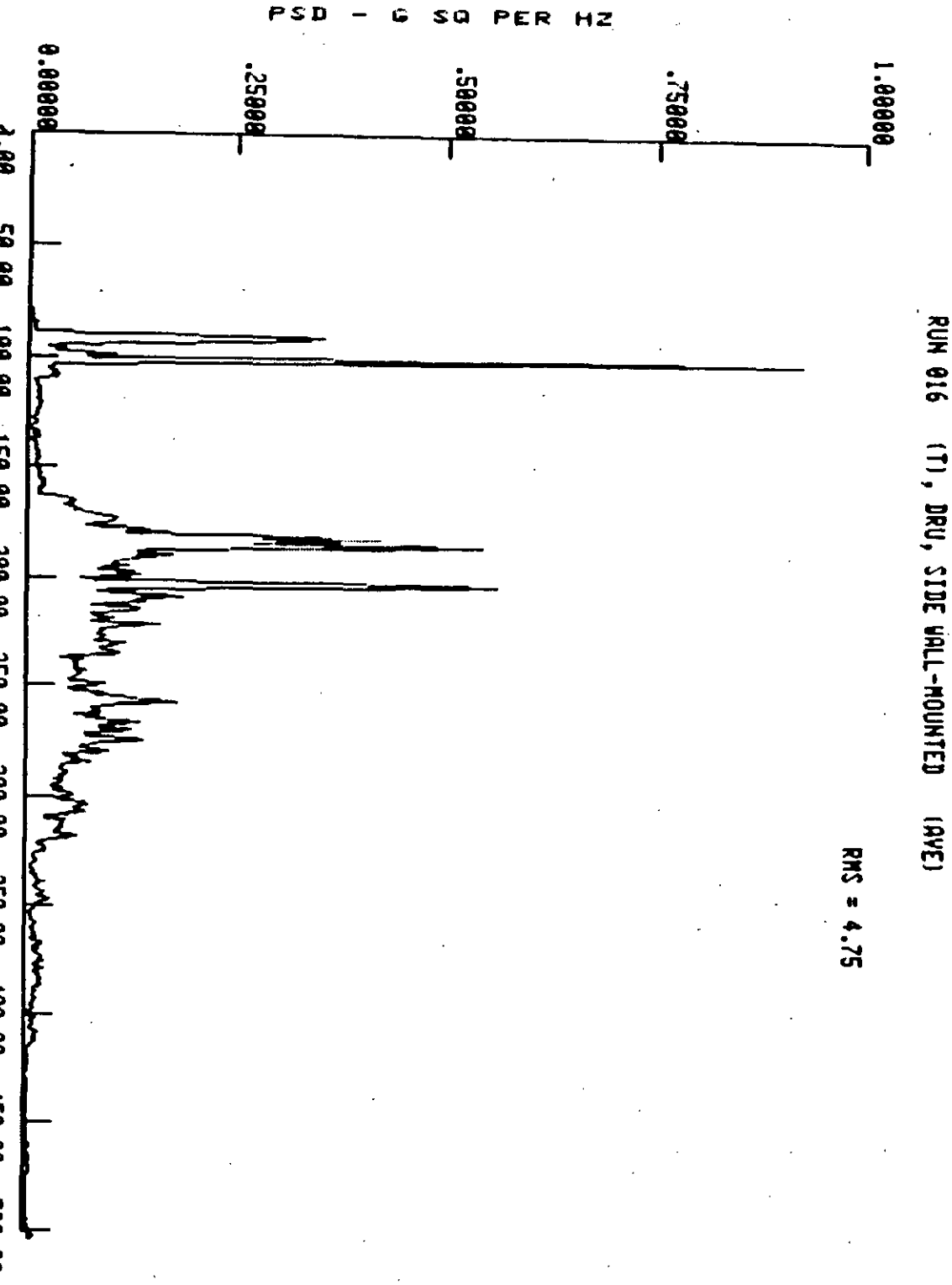


FIGURE 15. Representative Maximum Vibration Power Spectral Density - Lateral Axis

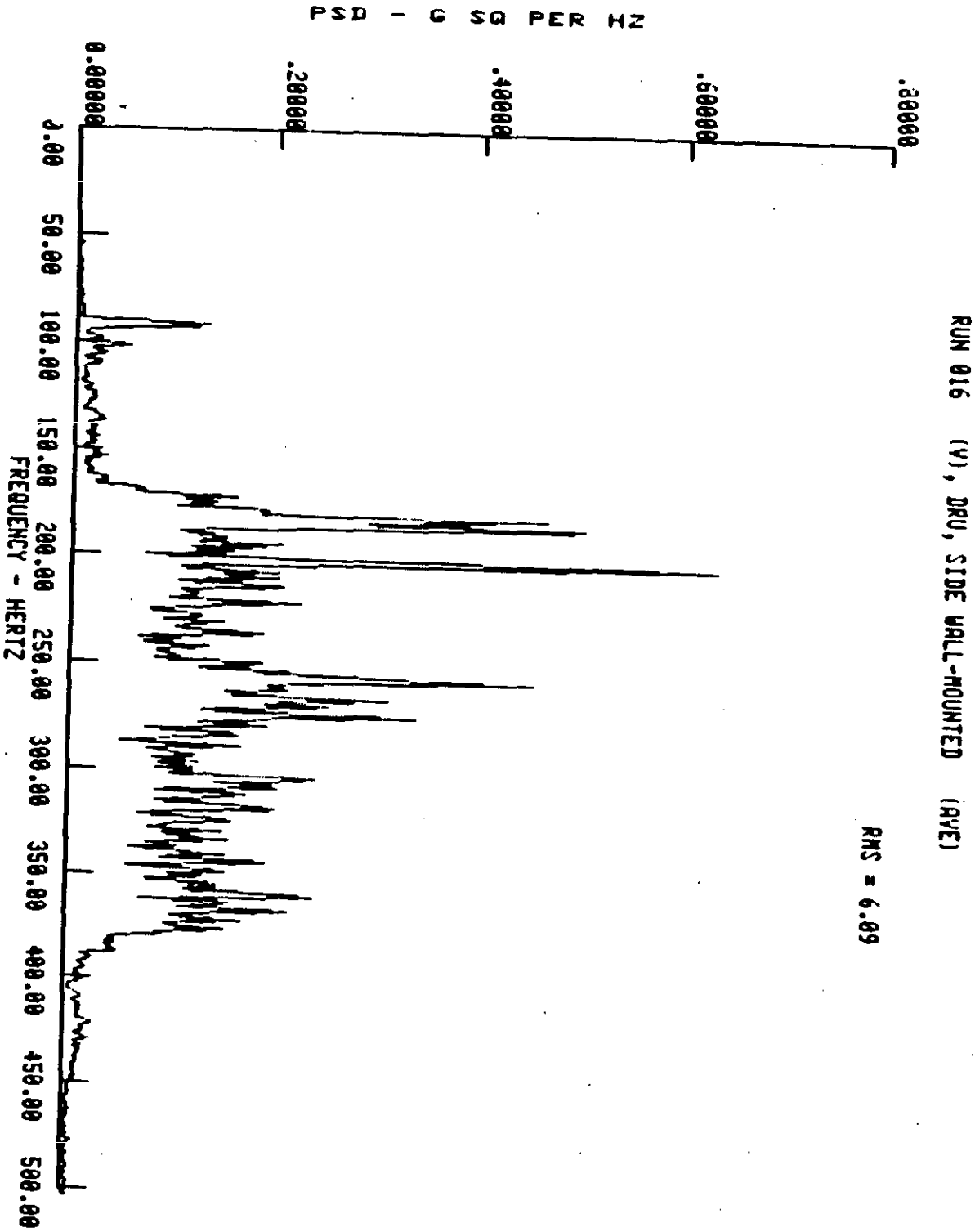


FIGURE 16. Representative Maximum Vibration Power Spectral Density - Vertical Axis

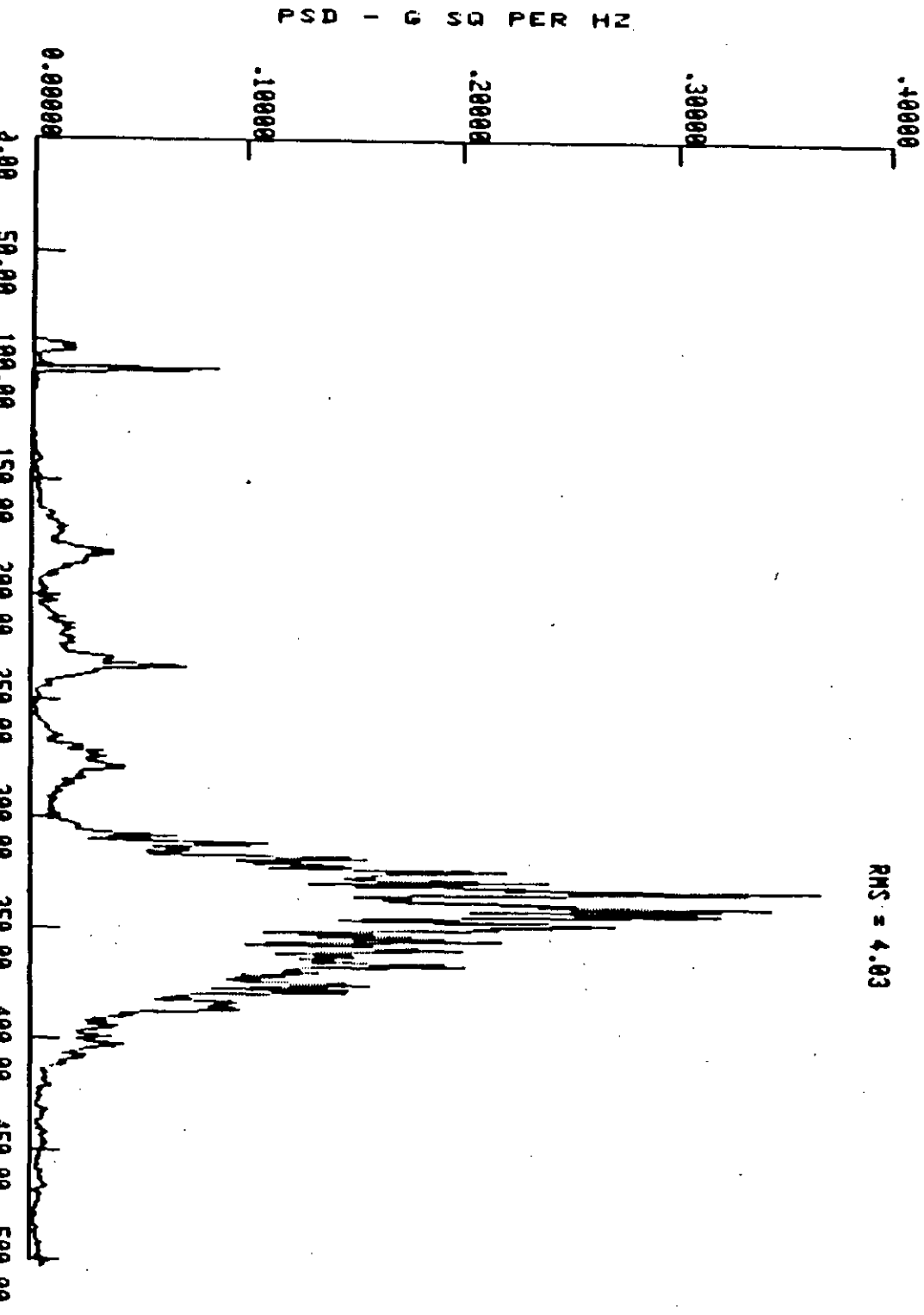


FIGURE 17 Representative Maximum Vibration Power Spectral Density - Longitudinal Axis

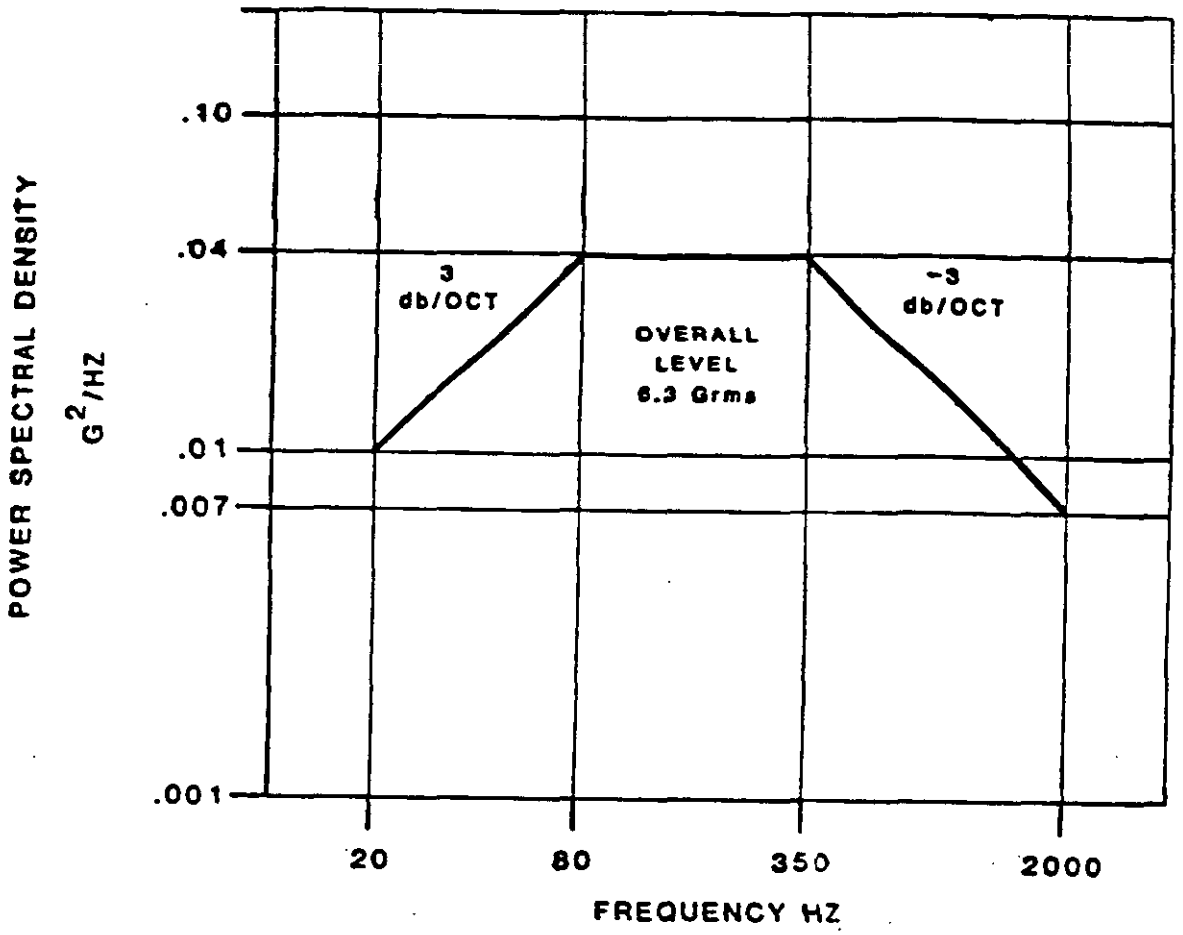


FIGURE 18 Random Vibration Spectrum

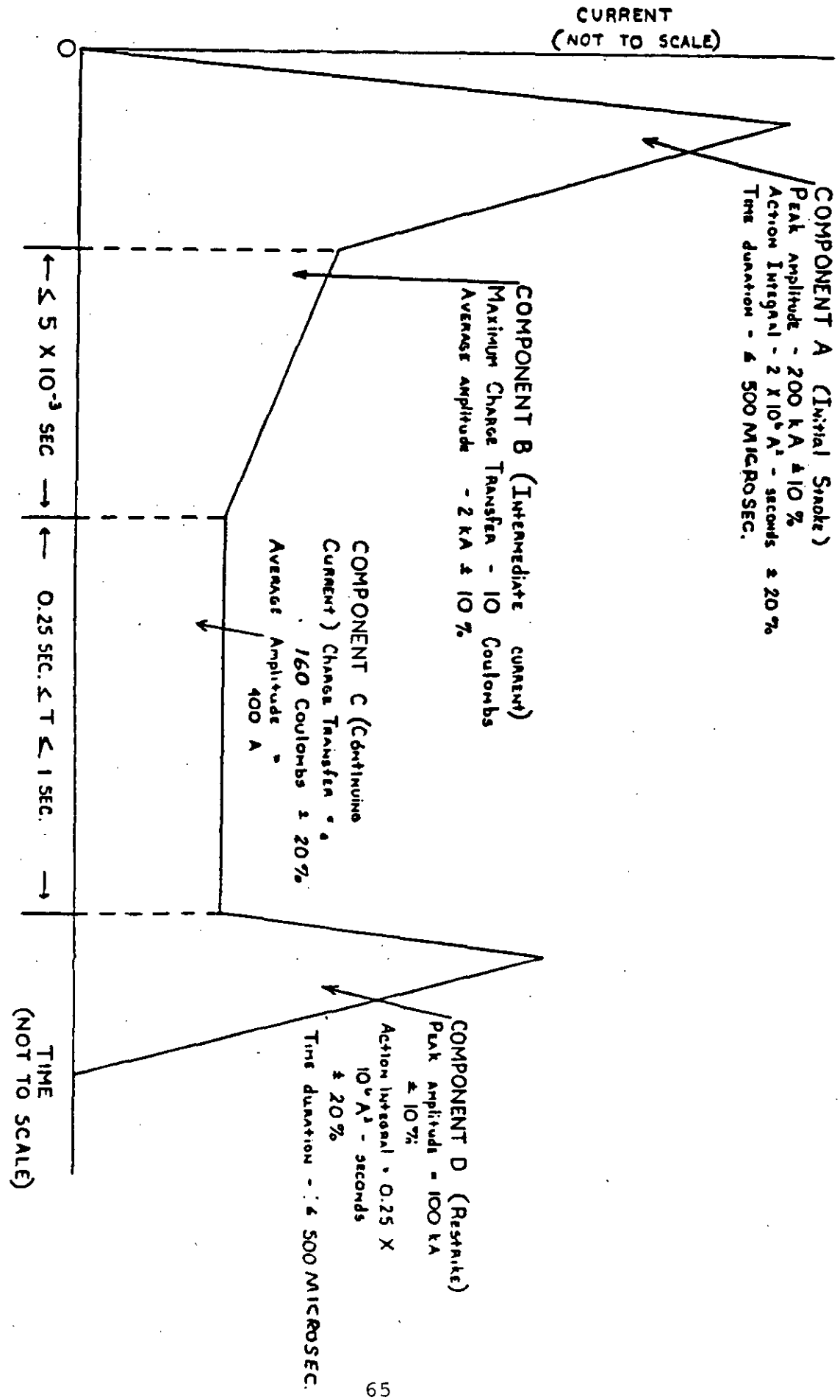


FIGURE 19 - Lightning Current Pulse

3.8 Design and construction.

3.8.1 Materials, processes, and parts. Materials, processes and parts shall be selected in accordance with MIL-P-11268.

3.8.1.1 Elapsed time indicator. The elapsed time meter shall be in accordance with Requirement 51 of MIL-STD-454 and MIL-M-7793.

3.8.1.2 Treatment and painting. All surfaces of the DRU shall be cleaned and treated as specified in MIL-F-14072. The exterior surfaces shall be painted Green 383 with chemical agent resistant, aliphatic, polyurethane paint in accordance with MIL-C-46168. Selection and protection of dissimilar metal combinations shall be in accordance with MIL-F-14072.

3.8.1.3 Marking and identification. The name plate shall be in accordance with Figure 20. Other required marking shall conform to MIL-STD-130 and Requirement 67 of MIL-STD-454.

3.8.1.4 Grounding. Ground connection to the chassis and to other mechanical parts shall not be made to complete electrical circuits, but only to eliminate high-potential ac points. The DRU shall be designed so that a D.C. power return circuit cannot be completed through the DRU chassis to a grounded vehicle chassis.

3.8.2 Nuclear survivability. The DRU shall not be damaged after exposure to the nuclear environment as specified in "Nuclear Survivability Criteria for the Modular Azimuth Position System (MAPS) equipment survivability category: man in truck or signal shelter, equipment exposed. The DRU is permitted to turn off, without damage, when exposed to nuclear events. After such a shutdown, the DRU shall not turn on until power has been disconnected and reapplied and when reinitialized shall require only a position update. The position update shall not use stored data. Design margins shall be in accordance with the following:

DESIGN MARGINS

	Design Margin Categories	
ENVIRONMENT	I	II
Initial Radiation		
Neutron Fluence	2 to 10	>10
Total Dose	2 to 10	>10
Gamma Dose Rate		
Upset	2 to 10	>10
Burnout	2 to 10	>10
Latchup	2 to 5	> 5

DESIGN MARGINS (Cont'd)

ENVIRONMENT	Design Margin Categories I	II
EMP		
(Voltage, Current ratio)	2 to 10	>10
Corresponding Design Margin for Power Dissipation	6 to 20dB	>20dB
Thermal		
Fluence	1.3 to 1.5	>1.5
Air-Blast		
Peak Overpressure	1.3 to 1.5	>1.5

Items are unacceptable when the design margin falls below the lower bound of Category I. If possible, the contractor shall avoid using items having design margins in the Category I range because there could possibly be significant hardness assurance/hardness maintenance impacts later in the life cycle (i.e. piecepart screens, lot sample testing). The contractor shall strive to incorporate Category II parts. Category II items shall be identified as Category IIA or IIB. The former refers to items which are special design/fabrications to achieve the nuclear hardness levels; the latter refers to items for which no special processes were incorporated to achieve the items' nuclear hardness.

3.8.3 NBC survivability. The DRU shall withstand the effects of an NBC contaminated environment as stated below:

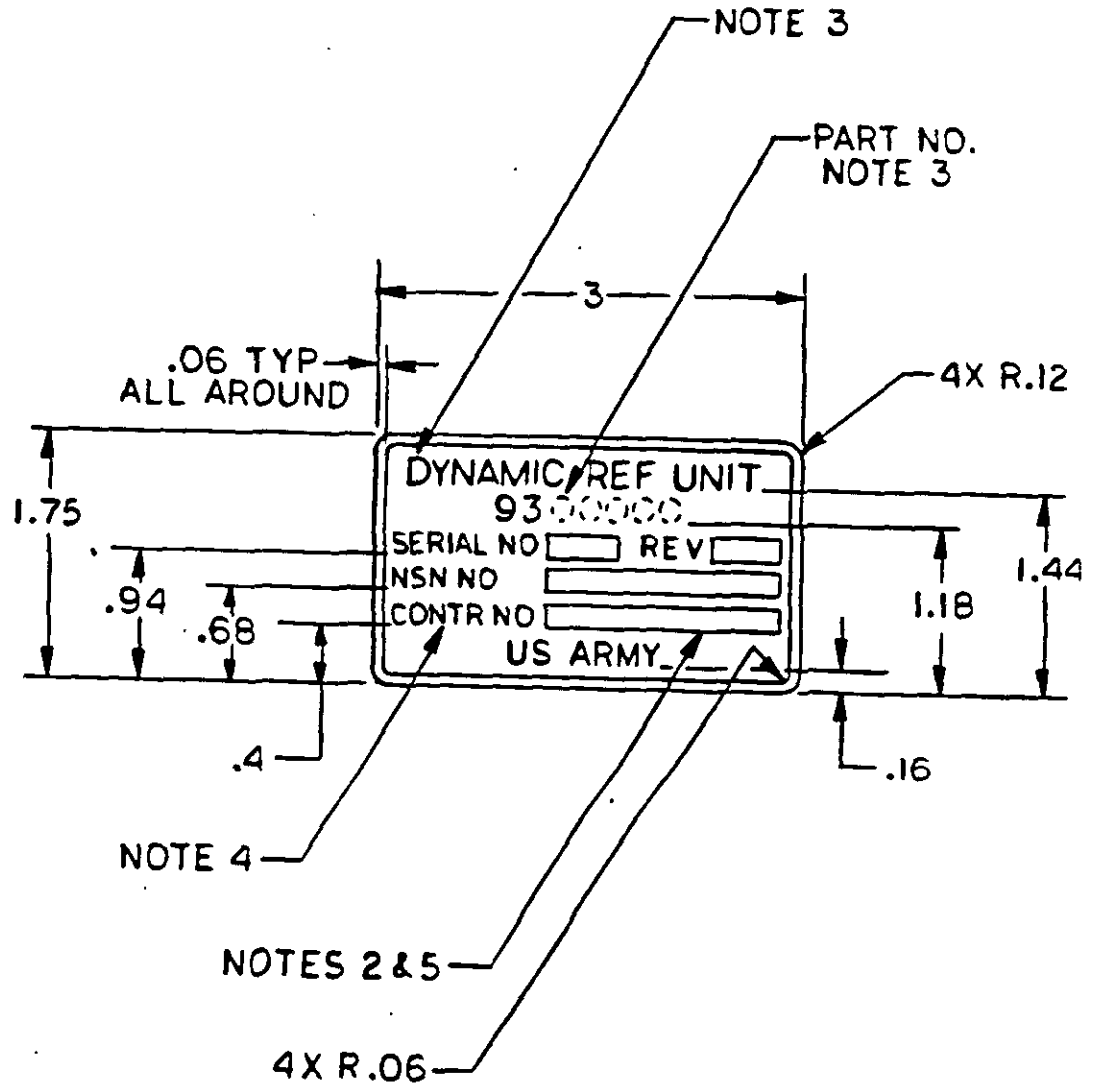
3.8.3.1 Decontamination.

a. Following decontamination, exterior surfaces on which NBC contaminates remain, or desorbed or reaerosolized from, shall not result in more than a negligible risk to unprotected personnel working 1 meter away.

b. When exposed to neutron fluence from a nuclear detonation that results in a total dose of 2,600 cGy (rad), the neutron induced activity in the DRU shall result in no more than a negligible risk to unprotected personnel arriving 2 hours after detonation and remaining at a distance of 1 meter for 12 hours. Risk levels are defined in "NBC Contaminants Survivability Criteria for Army Materiel".

c. No NBC contaminates or decontaminates shall be entrapped by the DRU.

d. Disassembly shall not be required to remove NBC contaminates or decontaminates.



NOTES:

1 - ANSI Y14.5M-82 APPLIES
2 - MATERIAL: PLATE, IDENTIFICATION, METAL FOIL, ADHESIVE BACKED, SPEC MIL-P-19834, TYPE I.
   A - CHARACTERS TO BE CENTERED IN THEIR RESPECTIVE AREAS: COMPOSE AS NECESSARY TO CONFORM TO DRAWING.
   B - BORDERS AND BLOCKS SHALL BE NATURAL COLOR, BLACK BACKGROUND.
   C - CHARACTERS TO BE .06 HIGH.
   D - CHARACTERS TO BE ALTERNATE GOTHIC NO. 3.
3 - CHARACTERS TO BE .18 HIGH.
4 - CHARACTERS TO BE .13 HIGH.
5 - BLOCKS TO BE 5/32 WIDE X LENGTH AS SHOWN.

FIGURE 20 : IDENTIFICATION PLATE

3.8.3.2 Hardness. The DRU shall not be damaged by exposure to:

a. Ten g/m^2 of thickened droplets of mustard (HD) or soman (GD) chemical agents having a mass median diameter (MMD) of (2-5 mm) and unthickened G-Agent (VX) chemical agent having MMD of 250 micrometers.

b. 10^5 spores/m^2 of biological agent 1-5 micrometers in size.

c. Four g/m^2 of insoluble radioactive contaminants 37-200 micrometers in size and 185 GB g/m^2 gamma activity.

d. The following decontaminates for a period of 1 hour:

(1) Super-Tropical Bleach (STB)
(2) DS2
(3) DANC
(4) Soap and Detergent
(5) Sodium Hydroxide
(6) High Test Hypochlorite (Calcium Hypochlorite)
(7) Sodium Carbonate
(8) Beto-Propialootone (BPL)
(9) Formaldehyde (Formalin)
(10) Ethylene Oxide
(11) Peracetic Acid (PAA)

The equipment shall be hardened to ensure that degradation over a 30-day period of no more than 5 percent in reliability, availability, and maintainability caused by 5 exposures to NBC contaminates, decontaminates, and decontaminating procedures.

3.8.3.3 Compatibility. DRU must have the ability to operate and be operated in a mission oriented protective posture of level four (4) (6.8.1.4).

3.8.4 Workmanship. Workmanship shall be in accordance with Requirement 9 of MIL-STD-454.

3.8.5 Interchangeability. Assemblies, and parts shall be interchangeable in accordance with Requirement 7 of MIL-STD-454.

3.8.6 Safety. The DRU shall conform with Requirement 1 of MIL-STD-454.

3.8.6.1 Environmental safety. The DRU shall not produce nor emit toxic by products capable of damaging the health of operators or their environment.

3.8.6.2 Explosive atmosphere. The DRU shall preclude ignition or explosion when operated in hazardous atmospheres.

3.8.7 Human performance/human engineering. The human performance and human engineering design principles of MIL-STD-1472; MIL-STD-1474, and MIL-H-46855 shall be applied to the DRU in order to achieve simple and error free ease of operation and maintenance. Areas requiring human factors engineering emphasis include, but are not limited to, personnel safety and equipment marking and nomenclatures.

3.8.8 Useful life. The DRU shall have a useful life of not less than 15 years under any combination of operation and storage.

3.9 Documentation. Documentation shall be in accordance with contract provisions.

3.10 Built-In-Test. Ninety-Five percent of the total of all malfunctions occurring in the DRU shall be detected and indicated by Built-In-Test (BIT). A spurious BIT indication (BIT indication of malfunction when there is no actual malfunction) shall be considered an undetected malfunction. The DRU shall not falsely indicate a VMS malfunction if a VMS is not being used in a particular configuration (3.5.8.8a).

3.10.1 BIT indications. Two BIT indications (DS) shall be provided on the DRU case as shown in Figure 7. DS-1 shall indicate by a green display that the DRU is receiving proper primary power. DS-2 shall indicate by a green display that the DRU is operating correctly. The BIT indicators shall indicate a failed condition by a black or non-illuminated display. Additional BIT information shall be provided via the serial data buses as follows: Failure of the DRU or VMS shall be indicated by setting bit 5 of STATUS character S2 and appropriate bits in the BUILT-IN-TEST Data message. Illegal operations or invalid input data shall trigger an alert indication in the STATUS word and set the appropriate bit in the ALERT DATA.

3.10.2. System built-in-test at turn-on. At turn-on, the DRU shall monitor vehicle primary power and determine whether the voltage level is within the specified limits (3.5.4.2). If primary power is outside limits, the DRU shall remain off, and DS-1 shall indicate a failed condition. If power is acceptable, the DRU shall energize.

3.10.3 System built-in-test during initialization. After being energized at turn-on or when commanded to RESTART, the DRU shall perform BIT of itself and the serial data bus circuitry. If the Configuration Definition Flag for Odometer/exclusive ZUPT Mode (3.5.8.8a) is set, the DRU shall perform VMS BIT (3.5.4.6). If the Configuration Definition Flag for the Odometer/Exclusive ZUPT Mode is reset, the DRU shall not perform BIT.

3.10.4 System built-in-test during a mission. The DRU shall continuously monitor vehicle primary power to determine whether the voltage level is within the specified limits (3.5.4.2) throughout the mission. If primary power is outside acceptable limits, the DRU shall shut off, and DS-1 shall indicate a failed condition.

The DRU shall monitor internal temperature. If the temperature is high enough to cause degraded accuracy, a status alert shall be indicated and bit 2 of ALERT DATA character D1 shall be set. Should the temperature become high enough to cause damage, the DRU shall automatically deenergize.

The DRU shall monitor its performance to determine if dynamic conditions have exceeded the DRU's capability to maintain specified accuracies. If rate loops become saturated or other performance thresholds are exceeded, a status alert shall be indicated and bit 1 of ALERT DATA character D3 shall be set. This alert shall not be reset until an align/realign and position update have been performed.

If a VMS is used, the DRU shall continuously evaluate the validity of odometer data. Should odometer data be persistently in error or if there is a significant loss of odometer data, the DRU shall follow the procedures for VMS failure as described in 3.5.3.2.1.3.

3.10.5. Data entry checking. All data received by the DRU shall be tested for reasonableness before being accepted. Any data outside the allowable range shall be rejected, and an Alert indicated in a STATUS DATA message. Alert indications for unreasonable data are listed below

Parameter	Allowable Range	Alert Char/Bit
Easting Northing	Allowable coordinates For Normal Zone, Extended Zone, and British National Grid.	D4/3, D5/2

Altitude Zone (D7, 30.1.1)	-400 to +3050m. 1 to 60 (N/A when operating in British National Grid).	D4/4, D5/2 D5/2
Zone (D6, 30.1.1)	0 to 60 (N/A when operating in British National Grid).	D5/2

The specific out of range data values which indicate parameters are not being updated (see 3.5.7) shall not trigger an Alert. Except for the command assigned to suppliers (30.2.12), the DRU shall not accept any commands, data (see 3.5.4.4.3.2), or changes to the computer software except those specified herein.

3.10.6 Input parameter verification.

3.10.6.1 Normal align. During Normal Align the DRU shall perform an input reasonableness test. If earth rate measurements indicate that the position used for initialization is unreasonable or if instrument biases have shifted to the extent that the values appear to be unreasonable, bit 4 of ALERT DATA character D2 shall be set. In addition, bits 4 and 5 of STATUS character S1 shall be reset. If the alert persists even when the initial parameters are correct, the proper operator response will be to replace the DRU.

3.10.6.2 Position update. After the DRU has entered the Survey mode, it shall compare any position coordinates entered via the serial data buses to the present internal estimate of DRU position. If the position differences are within the following tolerance: 3 (DRU Estimated Error) +X meters, the DRU shall accept them and complete the update. If the difference for any one of the updated parameters exceeds the tolerance, the entire update shall be rejected and an alert indicated in the STATUS word. ALERT DATA Character D4, bit 0, shall be set for excessive horizontal position error if the difference exceeds 3 (DRU Estimated Error) +X meters but does not exceed 12 (DRU Estimated Error) +Y meters. ALERT DATA Character D4, bit 1, shall be set for excessive Altitude error if the difference exceeds 3 (DRU Estimated Error) +X meters but does not exceed 12 (DRU Estimated Error) +Y meters. ALERT DATA Character D4, bit 3, shall be set if the difference for horizontal position exceeds 12 (DRU Estimated Error) +Y meters. ALERT DATA Character D4, bit 4, shall be set if the difference for Altitude exceeds 12 (DRU Estimated Error) +Y meters. (When an entire update has been rejected, the operator will check whether an error was made in the keyboard entry or whether the vehicle is at the correct survey control point. He will exercise judgment to determine whether the

update should be abandoned or whether he should follow procedures that will make the DRU accept the update in spite of the alert(s). In the extreme case, if ALERT DATA Character D4, bit 3 and 4 were set, the DRU shall accept an update if the data is reentered after RESTART is commanded). When an update has been rejected, the data shall be stored for comparison purposes in case the data is reentered. If the reentered data is not the same, or if the reentered data is the same but the vehicle has been moved, the data shall be tested against the normal tolerance and either accepted or appropriate alert(s) set, i.e., the same as if the data were being entered for the first time. If the reentered data is the same and the vehicle has not been moved, the update shall be accepted if D4/3 and/or D4/4 were not previously set. Otherwise, the update shall be rejected and the same alert(s) set. If either D4/3 alert or D4/4 alert is inhibiting an update, the operator may accomplish a partial update by proper choice of update groupings (3.5.7). For example, if an update of grouping b. (3.5.7) was attempted and rejected because D4/4 was set, the operator may choose grouping c. and accomplish an update. If D4/0 were also set, the update would be accepted with only one reentry of data, assuming all other criteria for update were met.

The X and Y tolerance values are:

Coordinate	X(m)	Y(m)
Horizontal Position	10	150
Altitude	5	50

3.11 Alerts. The DRU shall indicate an alert condition when any of the conditions defined in 30.4.6 are present. The DRU shall provide this information in an ALERT DATA message (30.4.6) upon receipt of a RETURN ALERT DATA command (30.2.7). The OVERRIDE ALERT command is sent automatically by the Prime System/CDU upon receipt of the ALERT DATA. Upon receipt of the OVERRIDE ALERT command, the DRU shall reset all overridable alerts. In the case of non-overridable alerts, the alerts shall not be reset until the appropriate action has occurred. Table V provides information and requirements pertinent to alerts.

TABLE V. Alerts

Bit		Alert	Overridable	Data Bus Requirements	Action Required Before Reset
D1	0	Previous Shutdown Abnormal	No	Sets alert on both data buses.	ACCEPT Position command.
	1	Spare			
	2	Sensor Over Temperature	No	Sets alert on both data buses.	Turn off system and let it cool down (system automatically turns off if temperture becomes dangerous). Resets alert at next turn on if the temperature is acceptable.
	3	Realign Interrupt	Yes	Sets alert on both data buses.	None. Resets alert on receipt of OVERRIDE ALERT command.
	4	Spare			
	5	Spare			
	6	Spare			
	7	Spare			
D2	0	Shutdown Interrupt	Yes	Sets alert only on the data bus which sent the SHUTDOWN command.	None. Resets alert on receipt of OVERRIDE ALERT command.
	1	Zero-velocity Interrupt	No	Sets alert on both data buses.	Completion of a zero-velocity update.
	2	Position Update Interrupt	No	Sets alert only on the data bus which sent the ACCEPT POSITION command.	ACCEPT POSITION command if S1/1 is set. If S1/1 is not set, resets automatcally after 60 seconds.
	3	Align Interrupt	No	Sets alert on both data buses.	RESTART command or new turn on.
	4	Align Terminated	No	Sets alert on both data buses.	RESTART command or new turn on. If alert persists, replacement of DRU.

TABLE V. Alerts (Cont'd)

Bit	Alert	Overridable	Data Bus Requirements	Action Required Before Reset
5	Stored Heading No Good	Yes	Sets alert on both data buses.	None. Resets alert on receipt of OVERRIDE ALERT command.
6	Align Initials Parameters Not Received	No	Sets alert on both data buses.	ACCEPT POSITION command or STORED HEADING ALIGN command. Automatically if Normal Align completed with stored parameters.
7	Spare			
D3 0	Motion with Pointing Device Out Of Travel Lock	Yes	Sets alert on both data buses.	None. Resets alert on receipt of OVERRIDE ALERT command.
1	Excessive Rates	No	Sets alert on both data buses.	RESTART command or new turn on.
2	Spare			
3	Spare			
4	Spare			
5	Motion During Position Update Request	Yes	Sets alert only on the data bus which sent the ACCEPT POSITION command.	None. Resets alert on receipt of OVERRIDE ALERT command.
6	Motion During Restart/ Realign Request	Yes	Sets alert only on the data bus which sent the RESTART/REALIGN command.	None. Resets alert on receipt of OVERRIDE ALERT command.
7	Motion During Shutdown Request	Yes	Sets alert only on the data bus which sent the SHUTDOWN command.	None. Resets alert on receipt of OVERRIDE ALERT command.

TABLE V. Alerts (Cont'd)

Bit	Alert	Overridable	Data Bus Requirements	Action Required Before Reset
D4 0	Northing/ Easting Update Excessive	Yes	Sets alert only on the data bus which sent the ACCEPT POSITION command.	None. Resets alert on receipt of OVERRIDE ALERT command.
1	Altitude Update Excessive	Yes	Sets alert only on the data bus which sent the ACCEPT POSITION command.	None. Resets alert on receipt of OVERRIDE ALERT command.
2	Spare			
3	Northing/ Easting Update Rejected	Yes	Sets alert only on the data bus which sent the ACCEPT POSITION command.	None. Resets alert on receipt of OVERRIDE ALERT command.
4	Altitude Update Rejected	Yes	Sets alert only on the data bus which sent the ACCEPT POSITION command.	None. Resets alert on receipt of OVERRIDE ALERT command.
5	Boundary Crossed	Yes	Sets alert on both data buses.	None. Resets alert on receipt of OVERRIDE ALERT command.
6	Hemisphere/ Zone Change	Yes	Sets alert only on the data bus which sent the ACCEPT POSITION command.	None. Resets alert on receipt of OVERRIDE ALERT command.
7	Spheroid Change	Yes	Sets alert only on the data bus which sent the ACCEPT POSITION command.	None. Resets alert on receipt of OVERRIDE ALERT command.
D5 0	Undefined Command Received	Yes	Sets alert only on the data bus which sent the undefined command.	None. Resets alert on receipt of OVERRIDE ALERT command.
1	Invalid Command Received	Yes	Sets alert only on the inhibited data bus if S1/0 is set.	None. Resets alert on receipt of OVERRIDE ALERT command.
2	Invalid Data Received	Yes	Sets alert only on the inhibited data bus.	None. Resets alert on receipt of OVERRIDE ALERT command.

TABLE V. Alerts (Cont'd)

Bit	Alert	Overridable	Data Bus Requirements	Action Required Before Reset
3	Configuration Data Not Present	No	Sets alert on both data buses.	ACCEPT CONFIGURATION DATA command.
4	Boresight Angles Not Present	No	Sets alert on both data buses.	ACCEPT BORESIGHT command.
5	Invalid Data Request	Yes	Sets alert only on the data bus which made the request.	None. Resets alert on receipt of OVERRIDE ALERT command.
6	Invalid Mode Request	Yes	Sets alert only on the data bus which made the request.	None. Resets alert on receipt of OVERRIDE ALERT command.
7	Invalid Update Request	Yes	Sets alert only on the data bus which made the request.	None. Resets alert on receipt of OVERRIDE ALERT command.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the government. The government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure that supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.1.2 General provisions. The component and subassembly inspection requirements of MIL-F-13926 form a part of the quality assurance provisions of this specification. Definitions of inspection terms shall be as listed in MIL-STD-109.

4.1.3 Test equipment and inspection facilities. The manufacturer shall insure that test and inspection facilities of sufficient accuracy, quality and quantity are established and maintained to permit performance of required inspections.

4.1.4 Witness of inspection. The government reserves the right to witness any of the inspections set forth in this specification. The supplier shall notify the government at least 5 working days in advance of performing any inspection. Witness by the government does not imply certification or acceptance of inspection results.

4.2 Classification of inspections. The inspections specified herein are classified as follows:

a. Qualification inspection.
b. First article inspection.
c. Quality conformance inspection.

4.3 Inspection conditions and precautions.

4.3.1 Submission of product. Unless otherwise specified by the contracting officer, inspection lot size, lot formation, and presentation of lots shall be in accordance with "Submission of Product" provision of MIL-STD-105.

4.3.2 Conditions. Unless otherwise specified all inspections shall be performed in accordance with the inspection provisions contained in the applicable Quality Assurance Provisions of MIL-F-13926 and the approved test plans and procedures. Test plans shall be prepared in accordance with the contract or purchase order.

4.4 Failures. The following failure, retest and rejection criteria will be used during all inspections unless otherwise specified.

4.4.1 Failure, retest and rejection criteria. The term FAILURE is defined to include part and component deterioration or breakage, damage evident from equipment inspection, and nonconformance to the requirements specified for performance, operational, or physical characteristics. A deviation beyond the tolerances established in this specification, in the approved test procedures, or in the equipment design is also considered a failure.

The following shall be classified as failures:

a. Adjustment, replacement, or repair of a part or assembly.

b. The need to reprogram the DRU.

c. Any northing or easting error within a static survey run exceeding 2 meters/hour*.

d. Any altitude error within a static survey run exceeding 4 meters/hour*.

e. Any BIT failure indications.

f. Failure to complete alignment or necessity of restarting alignment.

*NOTE: These values may vary depending on the contractor's test equipment and DRU mechanization. Any variation must be approved by the government.

Upon the occurrence of a failure, or whenever it becomes evident that an item will not meet a specified requirement or will not pass a test, the testing of the item for acceptance purposes shall be stopped.

After analyzing and reporting the failure, and taking corrective action in accordance with the quality program requirements, and with the approval of the government, the items shall be resubmitted for selection of samples and the test shall be repeated. Any rework or modification of the equipment voids all prior inspections and the government representative will make the determination whether or not to reperform tests conducted previously. For failures occurring during retest further testing and implementation of corrective action shall not take place unless approved in writing by the government representative.

4.5 Qualification inspection.

4.5.1 Qualification inspection. Qualification inspection shall be performed at a laboratory acceptable to the Government (See 6.4) on a sample unit produced with equipment and procedures normally used in production.

4.5.2 Inspection routine. Sample units shall be subjected to the qualification inspections specified in Table VI in the order shown. Test methods shall be in accordance with paragraphs listed in Table VI.

4.5.3 Failures. Failures in excess of those allowed in Table VI shall be cause for refusal to grant qualification.

4.5.4 Retention of qualification. To retain qualification, the contractor shall forward a report at 6-month intervals to the qualifying activity. The qualifying activity shall establish the initial reporting date. The report shall consist of:

a. A summary of the results of the tests performed for inspection of product for delivery (groups A and B, Tables VIII & IX), indicating as a minimum the number of lots that have passed, the number that have failed, and the group which they failed. The results of tests of all reworked lots shall be identified and accounted for.

b. A summary of the results of tests performed for periodic inspection (as specified in contract or purchase order), including the number and mode of failures. The summary shall include results of all periodic inspection tests performed and completed during the 6-month period. If the summary of the tests results indicates nonconformance with specification requirements, and corrective action acceptable to the qualifying activity has not been taken, action may be taken to remove the failing product from the qualified products list.

TABLE VI. Qualification inspection

Inspection	Number of Sample Units	Requirement Paragraph	Method Paragraph	Number of Failures Allowed
Physical Examination	All	3.5, 3.8 & 3.10.1	4.8.1	0
Operational Demonstration	All	3.6	4.8.6.1	0
Design Verification	1	3.5,3.6,3.8 & 3.10	4.8.7	0
Human Factor	1	3.8.7	4.8.4	0
Low Temperature	All**	3.7.1.1 & 3.7.1.3	4.8.5.5	0
High Temperature	All**	3.7.1.1 & 3.7.1.3	4.8.5.4	0
Temperature Shock	1	3.7.1.2	4.8.5.6	0
Solar Radiation	1	3.7.6	4.8.5.7	0
Altitude	1	3.7.2	4.8.5.3	0
Washdown	1	3.7.7	4.8.5.11	0
Shock	1	3.7.10.2 & 3.7.10.3	4.8.5.14	0
Vibration	1	3.7.11	4.8.5.15	0
Humidity	1	3.7.3	4.8.5.8	0
Fungus	1	3.7.9	4.8.5.13	0
Salt Fog	1	3.7.8	4.8.5.12	0
EMI-EMC	1	3.7.13 & 3.7.14	4.8.5.16 & 4.8.5.17	0
Electrostatic Discharge	1	3.7.15	4.8.5.18	0
Lightning	1	3.7.16	4.8.5.19	0
Reliability Demonstration	2	3.6.3	4.8.6.2	
Maintainability Demonstration	Note 2	3.6.4	4.8.6.3	
Snow	1	3.7.4	4.8.5.9	0
Icing	1	3.7.5	4.8.5.10	0
Performance Demonstration	3	3.5, 3.6, 3.8 & 3.10	4.8.6.4	0
NBC Survivability	1	3.8.3	4.8.5.20	0
Nuclear Survivability	1	3.8.2	4.8.5.21	0
Explosive Atmosphere	1	3.8.6.2	4.8.5.22	0
Nuclear Hardness	1	3.8.3.2	4.8.8	0

Note 1: Individual test items to be selected from the total number available by the government representative. Note 2: All units shall participate as failures occur. One unit may be used to simulate failures as necessary.

**The temperature storage test shall be performed on 3 units.

Failure to submit the report within 30 days after the end of each 6-month period may result in loss of qualification for the product. In addition to the periodic submission of inspection data, the contractor shall immediately notify the qualifying activity at any time during the 6-month period that the inspection data indicates failure of the qualified product to meet the requirements of this specification.

In the event that no production occurred during the reporting period, a report shall be submitted certifying that the company still has the capabilities and facilities necessary to produce the item.

4.6 First article (initial production) approval. The requirement for first article approval and the responsibility (Government or contractor) for first article testing shall be as specified in the contract. The sample for first article approval tests shall consist of five DRU's. The sample shall be manufactured in the same manner, using the same materials, equipment, processes, and procedures as used in regular production. All parts and materials, including packaging and packing, shall be obtained from the same source of supply as used in regular production.

4.6.1 Government testing. When the Government is responsible for conducting first article approval tests, the contractor, prior to submitting the sample to the government, shall inspect the sample to insure that it conforms to all requirements of the contract and submit a record of this inspection, with the sample, including certificates of conformance for materials.

4.6.2 Contractor testing. When the contractor is responsible for conducting first article approval tests, the sample shall be inspected by the contractor for all the requirements of the contract. The sample and a record of this inspection, including certificates of conformance for materials, shall be submitted to the government for approval. The Government reserves the right to witness the contractor's inspection.

4.6.3 First article inspections and tests. Unless otherwise specified in the contract or purchase order or stipulated by the Contracting Officer, the first article sample shall be subjected to all inspections and tests in Table VII and to all requirements of the applicable drawings. All units selected for First Article Inspection shall have successfully passed Quality Conformance Inspection.

TABLE VII. First article inspection

Inspection	Number of Sample Units	Requirement Paragraph	Method Paragraph
Design Verification	1	3.5,3.6,3.8 & 3.10	4.8.7
Low Temperature	3	3.7.1.1 & 3.7.1.3	4.8.5.5
High Temperature	3	3.7.1.1 & 3.7.1.3	4.8.5.4
Temperature Shock	1	3.7.1.2	4.8.5.6
Washdown	1	3.7.7	4.8.5.11
Shock	1	3.7.10.2 & 3.7.10.3	4.8.5.14
Vibration	1	3.7.11	4.8.5.15
EMI	1	3.7.13	4.8.5.16
Electrostatic Discharge	1	3.7.15	4.8.5.18

4.7 Quality conformance inspection.

4.7.1 Inspection of product for delivery. Inspection of product for delivery shall consist of groups A and B inspections.

4.7.1.1 Group A inspection. Group A inspection shall consist of the inspections specified in Table VIII, and shall be made on the same set of sample units, in the order shown.

4.7.1.1.1 Sampling plan. Group A tests shall be performed on 100 percent of the product supplied under this specification.

4.7.1.2 Group B inspections. Group B inspection shall consist of the inspections specified in Table IX, in the order shown. They will be performed on sample units that have been subjected to and have passed group A inspection.

4.7.1.2.1 Sampling plan. Group B tests shall be performed in accordance with MIL-STD-105, general inspection level II.

4.7.2 Failures. All failures shall be reported and analyzed. A summary of all failures shall be provided to the government as required in the contract. In addition to paragraph 4.4 the following shall apply to failures occurring in the Group A inspections.

If no failures occur that require removal of the DRU from the temperature chamber, at the conclusion of the temperature cycling sequence, the standard deviation about the mean of the azimuth, pitch, and roll data (20 recorded data each) shall be calculated. No datum shall be excluded, and a single calculation shall be made for each attitude, combining both high and low temperature data. If the standard deviation for azimuth exceeds 1.0 mil, or the standard deviation for either pitch or roll exceeds 0.5 mil, the unit shall be rejected and, after adjustment/repair, subjected to the entire random vibration and temperature cycling sequence.

If a failure(s) requires the DRU to be removed from the temperature chamber for adjustment, replacement or repair of a part or assembly, at the conclusion of the temperature cycling sequence, the standard deviation about the mean of the azimuth, pitch, and roll data shall be calculated using only the data recorded after the DRU is returned to the temperature chamber (a minimum of 6 recorded data each). Data recorded before removal(s) shall be excluded, but no datum shall be excluded from the calculations after the DRU is

returned to the temperature chamber for the final temperature cycling sequence. A single calculation shall be made for each attitude, combining both high and low temperature data. If the calculated value of azimuth is 1.0 mil or less, and the calculated values for pitch and roll are 0.5 mil or less, the unit shall have passed the test. If any of these values are exceeded, the contractor shall be permitted at his discretion to perform additional cycles to increase the total sample size up to a total of 20 recorded data each. At the conclusion of each additional cycle, the standard deviation of the mean of each attitude shall be recalculated, combining both high and low temperature data and excluding no datum of any attitude recorded beginning when the DRU was returned to the temperature chamber. If the recalculated value of the azimuth is 1.0 mil or less, and the recalculated values for pitch and roll are 0.5 mil or less, the unit shall have passed the test. If any of these values are exceeded, the contractor shall be permitted to perform additional cycles to attempt to bring the results of the calculations within the stated specifications. If after additional cycles, any of the calculated values exceed the stated specification, the unit shall be rejected and after adjustment/repair subjected to the entire random vibration and temperature sequence.

4.8 Method of inspections.

4.8.1 Physical examination. The Equipment shall be examined for the following defects:

a. Configuration not as specified. Configuration record incomplete or inaccurate.
b. Assemblies, parts or components missing or not as specified.
c. Materials not as specified.
d. Safety devices missing or not as specified.
e. System interfaces not as specified.
f. Treatment and painting not as specified.
g. Workmanship not as specified.
h. Assembly incomplete or incorrect.
i. Identification marking missing, incomplete or not legible.

The presence of one or more defect(s) shall constitute a failure of the examination.

TABLE VIII. Group A inspection.

NO.	CHARACTERISTIC	REQUIREMENT PARAGRAPH	TEST METHOD PARAGRAPH
	100% Inspection		
1.	Physical Examination	3.5, 3.8 & 3.10.1	4.8.1
2.	ESS-Vibration	3.7.12	4.8.2.1
3.	ESS-Temperature	3.7.1.4	4.8.2.2
4.	Quality Verification Test	3.5, 3.6, 3.8, 3.10, & 3.11	

TABLE IX. Group B inspection.

NO.	CHARACTERISTIC	REQUIREMENT PARAGRAPH	TEST METHOD PARAGRAPH
	MAJOR: 0.65% DEFECTIVE		
101.	Washdown	3.7.7	4.8.5.11

4.8.2 Environmental Stress Screening. The DRU shall be subjected to the ESS vibration and temperature tests according to Figure 21 and the following.

4.8.2.1 ESS-vibration. The DRU shall be mounted on a vibration device capable of performing the vibration levels as specified. The DRU shall be subjected to the levels as specified in paragraph 3.7.12.

4.8.2.2 ESS-temperature cycling. The DRU shall be placed in a temperature chamber and subjected to the cycles as specified in the requirements of paragraph 3.7.1.4.

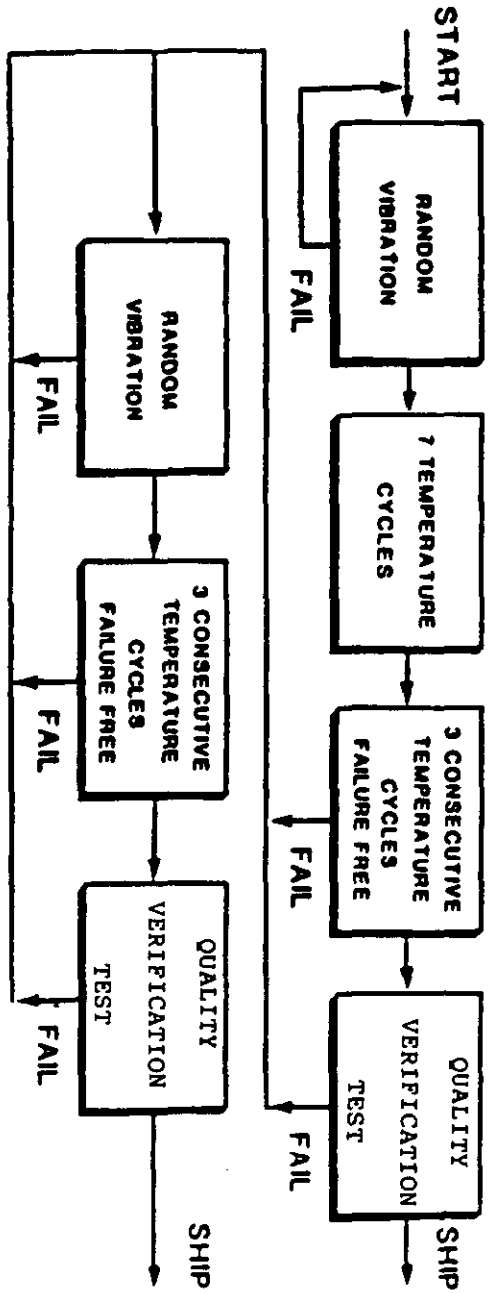
4.8.3 Quality Verification Tests. Quality Verification Tests shall simulate normal operational conditions and verify BIT, modes of operating, updating of parameters, communication interfaces, VMS interface, discretes, power supply outputs, correct operation with high and low input voltages, turnon/turnoff and functional characteristics by measurement. Failure to meet specified values for any monitored parameter, any out of tolerance condition, or malfunction, shall constitute failure of the test and rejection of the DRU.

Quality Verification Tests shall include an azimuth alignment accuracy test. The data sample size shall be in accordance with the approved test procedure. No data shall be excluded from the RMS calculation. If the azimuth error is 1.0 mil RMS, or less, the unit shall have passed the test. If the azimuth error exceeds 1.0 mil, RMS, the unit shall be rejected.

Quality Verification Tests shall include pitch and roll accuracy tests. The data sample shall be in accordance with the approved test procedure. No data shall be excluded from a RMS calculation. If the pitch error and the roll error are 0.5 mil RMS, or less, the unit shall have passed the test. If either the pitch error or roll error exceeds 0.5 mil, RMS, the unit shall be rejected.

Quality Verification Tests shall include position drift and survey azimuth accuracy tests.

4.8.4 Human factors examination. The equipment shall be examined by trained human factors engineers for compliance with requirements of 3.8.7.



NOTE: A FAILURE DURING ANY OF THE FIRST 7 TEMPERATURE CYCLES REQUIRES ONLY A SUCCESSFUL REPEAT OF THE FAILED CYCLE(s).

FIGURE 21 Test Sequence of Events

Failure of the equipment to comply with the requirements of 3.8.7 shall constitute failure of this test.

4.8.5 Environmental tests.

4.8.5.1 General. Where a test calls for a simulated survey mission, the DRU shall be operated in the ZUPT mode with four minute "travel" periods between 30 second ZUPTS. The DRU shall be operated for equal time periods with the input supply voltage at the nominal level, the lowest specified limit, and the highest specified limit.

During a simulated survey mission the DRU shall be tested for: normal BIT, ALERT and STATUS indications; horizontal position and altitude values within approved limits; and azimuth drift within approved limits.

Failure to meet the specified value of any parameter shall constitute failure of the test.

4.8.5.2 Pre and post testing. Prior to and after each test, where the equipment is tested in a static mode (chamber and mechanical tests), a series of tests shall be performed to verify proper operation of the equipment. The equipment shall be inspected for physical damage, loose hardware, degradation of materials or any other defects after each test. Should the system set up remain the same from one major test to the next, the post-test verification test may serve as the pre-test verification test for the next major test.

4.8.5.3 Altitude. Low Pressure (altitude) tests shall be performed on the DRU in accordance with MIL-STD-810, Method 500.2, procedures I (non-operating) and II (operating). A simulated altitude of 40,000 feet shall be maintained for 1 hour during the non-operating test. The operating test shall consist of a one hour simulated survey mission at a simulated altitude of 10,000 feet. The rate of altitude change shall not exceed 10 meters/second. The DRU shall meet the requirements of paragraph 3.7.2.

4.8.5.4 High temperature. A high temperature test shall be performed on the DRU in accordance with MIL-STD-810, Method 501.2, procedures I (storage) and II (operating). The storage test shall be conducted at a temperature of +160°F for seven 24 hour periods (total of 168 hours). The temperature cycle for the operating test shall be in accordance with Induced Conditions as listed in Table 501.2-I of MIL-STD-810 (omit humidity cycle). The operating test duration shall be a minimum of 72 hours and simulated survey missions shall be performed whenever the chamber temperature (see 3.7.1.1 & 3.7.1.3) is +140°F or lower.

4.8.5.5 Low temperature. Low temperature tests shall be performed on the DRU in accordance with MIL-STD-810, Method 502.2, Procedures I and II. Procedure I (storage) test duration shall be a minimum of 72 hours at a stabilized temperature of -60°F. Procedure II (operational) shall include a 24 hour nonoperational cold soak at -60°F, followed by temperature stabilization at -50°F for a 6-hour simulated DRU survey mission (See 3.7.1.1 & 3.7.1.3).

4.8.5.6 Temperature shock. Temperature shock tests shall be performed on the DRU in accordance with MIL-STD-810, Method 503.2, between the limits of -60°F (-51°C) and +160°F (+71°C). The DRU shall meet the requirements of paragraph 3.7.1.2.

4.8.5.7 Solar radiation. Solar Radiation tests shall be performed on the DRU in accordance with MIL-STD-810, Method 505.2, Procedure I and paragraph 3.7.6 using the HOT-DRY diurnal cycle. Perform a 6 hour simulated survey mission at the peak temperature for each of the three diurnal cycles.

4.8.5.8 Humidity. Humidity tests shall be performed on the DRU in accordance with MIL-STD-810, Method 507.2, Procedure III and paragraph 3.7.3. In the last hour of the fifth and tenth cycles, while maintaining current chamber conditions, perform a simulated survey mission.

4.8.5.9 Snow. A snow test shall be performed using a suitable environmental chamber or climatic test area to show that the DRU operates in snow in accordance with 3.7.4. Perform a simulated survey mission during the last hour of the test.

4.8.5.10 Icing. An Icing/Freezing Rain test shall be performed on the DRU in accordance with MIL-STD-810, Method 521.0 to prove that the DRU operates correctly when exposed to the Icing Conditions specified in 3.7.5. Perform a simulated survey mission during the last hour of the test.

4.8.5.11 Washdown. The DRU shall not be damaged nor leak when exposed to a water stream from a 1-inch diameter nozzle fed by a pressure of 50 $\pm$ 5 pounds per square inch for a period of 30 minutes. The stream shall be directed onto each face, except the DRU mounting surface, of the DRU from a distance of 3 feet, for equal periods. At the start of the test the DRU temperature shall be at least 10°C (18°F) higher than the water temperature. Only the specified mating connectors or cover (J3) are permitted to cover connectors. Failure to operate as specified or evidence of damage or leakage shall constitute failure of the test. The DRU shall pass the requirements of paragraph 3.7.7.

4.8.5.12 Salt Fog. Salt Fog tests shall be performed on the DRU in accordance with MIL-STD-810, Method 509.2 using the conditions specified in 3.7.8. Subject the DRU to three cycles of testing. A cycle consists of exposure to the salt fog for twenty four hours, followed by twenty four hours of drying out at room temperature. Perform a simulated survey mission during the last hour of each of the three drying out cycles.

4.8.5.13 Fungus. Fungus tests shall be performed on the DRU in accordance with MIL-STD-810, Method 508.3, for a period of 90 days. The DRU shall meet the requirements specified in paragraph 3.7.9.

4.8.5.14 Shock.

4.8.5.14.1 Transportation. Shock tests shall be performed on the DRU in accordance with MIL-STD-810, Method 516.3 Procedure I and paragraph 3.7.10.2. Peak Amplitude shall be 40g with a time duration of 6-9 msec. The DRU shall be operating in the Survey Mode when the shock pulses are applied. Run a one hour simulated survey mission after the six shock pulses have been applied to each axis.

4.8.5.14.2 Bench Handling. Bench Handling tests shall be performed on the DRU in accordance with MIL-STD-810, Method 516.3, Procedure VI and paragraph 3.7.10.3.

4.8.5.15 Vibration. Vibration tests shall be performed on the DRU in accordance with MIL-STD-810, Method 514.3, Category 8, Procedure I. The DRU shall be subjected to a series of vibration profiles which are contained in Appendix G. Appendix G contains five vibration profiles for the DRU vertical axis ($\overline{Z}_C$) (V01 - V05), five for the DRU transverse axis ($\overline{Y}_C$) (T01 - T05) and five for the longitudinal axis ($\overline{X}_C$) (L01 - L05). All these profiles depict the DRU mounted on the M109. The DRU shall be subjected to a 54 minute vibration test using each of the vibration profiles. The total test time for each axis shall be 270 minutes. The total test time for the three axes shall be 810 minutes. During exposure periods the DRU shall be operating in the Survey Mode and ZUPTs shall not be performed. The procedure for verification of the performance (accuracy) criteria shall be detailed in the government approved test procedures. The DRU shall meet the requirements of paragraph 3.7.11.

4.8.5.16 EMI-EMC. The DRU shall be subjected to EMI-EMC tests in accordance with part 4 of MIL-STD-461, MIL-STD-462 and MIL-STD-463. Field strengths for RSO3 shall be as specified in 3.7.14.

4.8.5.17 Magnetic compatibility. The DRU shall be tested, in a facility approved by the government, to ensure that exposure to a 3 gauss steady-state magnetic field, oriented vertically and horizontally in three orthogonal directions, shall not result in degradation in performance. The DRU shall pass the requirements of paragraph 3.7.13.

Any demonstrated sensitivity to applied external magnetic fields shall constitute failure of this test.

4.8.5.18 Electrostatic discharge. The equipment shall be connected to an electrostatic generator through a 1000 pf high-voltage cable. After being charged to a potential difference of 300,000 volts, the equipment shall be discharged through a 500 ohm resistor. The equipment shall be subjected to a total of 30 charge/discharge cycles using both positive and negative charging polarities and at least 3 different discharge points. Damage to or failure of the equipment to perform as specified, after exposed to the charge/discharge cycles, shall constitute failure of the test. The DRU shall meet the requirements of paragraph 3.7.15.

4.8.5.19 Lightning. The equipment shall be installed in a lightning discharge test facility and subjected to 10 lightning pulses, approximating Figure 17, at a distance of 10 meters. The equipment shall be operating in the Survey Mode when subjected to half the strikes and inactive for the remaining exposures. The DRU is permitted to shutdown when exposed to lightning strikes. This shutdown is defined as an abnormal shutdown.

4.8.5.20 NBC survivability. The DRU shall be analyzed or tested for conformance with the requirements in "NBC Contaminants Survivability Criteria for Army Materiel". Testing shall be conducted at facilities approved by the government using accept/reject criteria established by appropriate Government Agencies. The DRU shall pass the requirements of paragraph 3.8.3.

4.8.5.21 Nuclear survivability. The DRU shall be analyzed or tested for conformance with paragraph 3.8.2. Testing shall be conducted at facilities approved by the Government.

4.8.5.22 Explosive atmosphere. Explosive Atmosphere tests shall be performed on the DRU in accordance with MIL-STD-810, Method 511.2, Procedure I and paragraph 3.8.6.2 at a simulated test altitude of 10,000 feet and a temperature of +140°F.

4.8.6 Demonstrations.

4.8.6.1 Operational demonstrations. The DRU, installed in a wheeled vehicle, shall be tested for two missions over a government approved test course. The time to traverse the test course shall be approximately 6 hours. In addition to the initialization point, the test course shall have 12 survey control points, spaced approximately equally in time, for measurement of DRU survey parameters. The conditions for each mission shall be:

CONDITION	MISSION 1	MISSION 2
Normal Align	X	X
Odometer Aided	X	
Exclusive ZUPT mode		X
Mounting, $\alpha = \emptyset$, $\beta = \emptyset$, $\gamma = \emptyset$	X	X

The following parameters shall be measured:

a. Alignment time.
b. Time of each zero-velocity stop and duration of each zero-velocity stop.
c. Time of each realignment and duration of each realignment.
d. DRU position, altitude, azimuth, pitch, roll and distance traveled at the initialization point and each survey control point.

Using the above data, the position, altitude, azimuth, pitch and roll error characteristics shall be calculated.

The DRU shall meet the requirements of paragraph 3.6. Failure to meet the specified value of any parameter shall constitute failure of the test.

4.8.6.2 Reliability demonstration.

4.8.6.2.1 General. The DRU shall be tested as specified herein. The "accept" and "reject" criteria shall be in accordance with MLD-STD-781, Test Plan XXC. The upper and lower test MTBFs shall be 4000 and 2000 hours respectively. The contractor shall report, analyze and determine corrective action for all failures which occur during the reliability demonstration. The contractor shall treat all failures as chargeable. The government will score all failures. The DRU shall meet the requirements of paragraph 3.6.3.

4.8.6.2.2 Test conditions and procedures. The DRU reliability demonstration shall consist of two types of test cycles, a functional survey and a chamber test. One functional test cycle shall be performed for each six chamber cycles. The following performance parameters shall be measured and evaluated to determine if the DRU is functioning properly:

a. Horizontal Position.
b. Altitude.
c. Azimuth.
d. Pitch.
e. Roll.
f. Initial Alignment Time.

Test records shall be maintained in accordance with MIL-STD-781, Appendix D, Section 30.

4.8.6.2.2.1 Chamber test. The DRU shall be used in Configuration C, Figure 3, for chamber testing. The DRU shall be operated as a free inertial survey system with four minute simulated "Travel" periods between zero-velocity updates. The chamber test cycle shall be in accordance with Figure 22. The procedure for verification of the performance (accuracy) criteria shall be detailed in the government approved test procedures.

Chamber test conditions and procedures will be as specified in MIL-STD-781, Appendix B, Section 50.2 and Appendix D with the following changes:

a. Voltages.

(1) Maximum: 32V.
(2) Minimum: 16.4V.
(3) Nominal: 24V.

At the start of the test the input voltage shall be adjusted above the minimum turn on voltage, and then reduced to the minimum operating voltage.

b. Gun fire shock. The DRU shall be exposed to stimulated gun fire shocks as shown in Figure 22. The shock spectra shall be in accordance with Figures 23, 24 and 25, with an equal number of exposures in each axis. In the vertical ($\bar{Z}_C$) and longitudinal ($\bar{X}_C$) axes tests, half of the shock pulses shall be applied using the magnitudes shown in the upper level curves of Figures 23 and 25 and half using the lower level curves. The acceleration levels of the test control signal shall not deviate from the specified requirements

by more than +6-3dB over the entire test frequency range. However deviations of -6dB in the test control signal may be granted for frequencies greater than 500 Hz due to fixture resonance, test item resonance, or facility limitations. The cumulative bandwidth over which this reduction shall be allowed cannot be greater than 5% of the test frequency range (see Figure 26). In no case shall the acceleration levels be more than -6dB below the specified requirements. No deviation shall be granted for frequencies below 500 Hz. Tolerance levels in terms of dB are defined as:

$$dB = 20 \log (W_1/W_0)$$

where:

W_1 = measured acceleration level in g's.

W_0 = specified level in g's.

A separate Gun Fire Shock test may be conducted instead of performing the test shown in Figure 22. If a separate test is performed, the DRU shall be subjected to 32 shock pulses for each axis using the shock spectra in Figures 23, 24 and 25. The DRU shall be operating in the survey mode when the shock pulses are applied. ZUPTS are permitted between shock pulses. Verify that BIT and STATUS indications are normal after application of the pulses. Verify that position and altitude readings are stable and that azimuth drift is acceptable. After application of the 32 shock pulses to each axis perform a functional survey test followed by six chamber cycles. Continue this procedure until twenty four chamber cycles have been completed. The next step is to apply the 32 shock pulses and continue repeating the procedure.

c. Temperature.

(1) Hot soak: +160°F (+71°C),
(2) Operating range: -50°F (-46°C) to +140°F (+60°C).

d. Vibration. The DRU shall be subjected to the vibration levels contained in Appendix H, for 15 minutes periods, at the intervals indicated in Figure 22. Appendix H contains five *vibration profiles obtained from the DRU vertical axis ($\overline{Z}_C$) (V01 -* V05) with the DRU mounted on the M109, five vibration profiles obtained from the DRU longitudinal axis ($\overline{X}_C$) (L01 - L05), one obtained from the DRU vertical axis (CUCV VERT) with the DRU mounted on the CUCV, and one obtained from the DRU longitudinal axis (CUCV LONG) with the DRU mounted on the CUCV. The DRU shall be vibrated for equal amounts of time in the vertical and longitudinal axes. In each axis, the DRU shall be vibrated for 50% of the time using the CUCV profile and 10% of the time using each of the five M109 profiles.

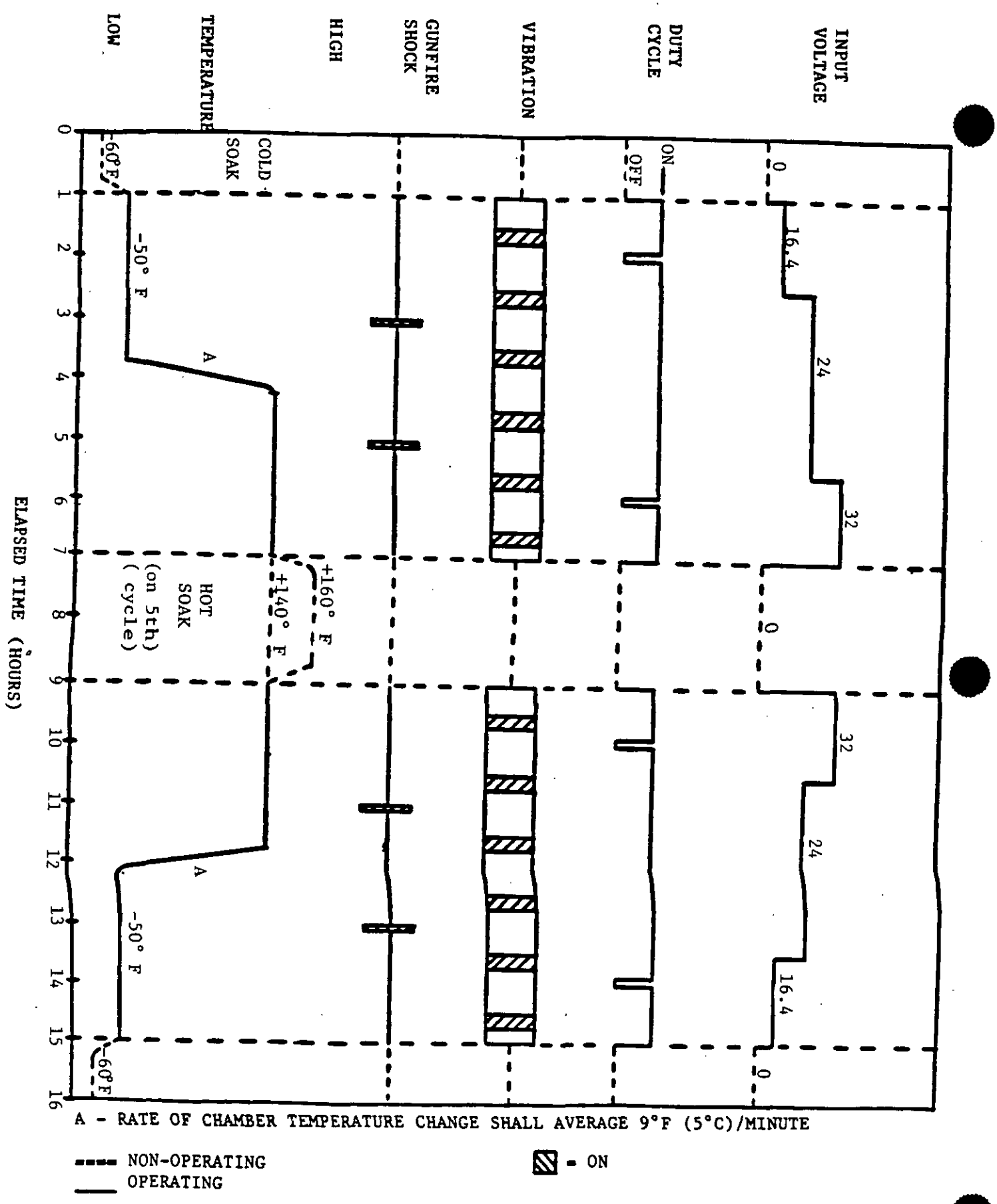
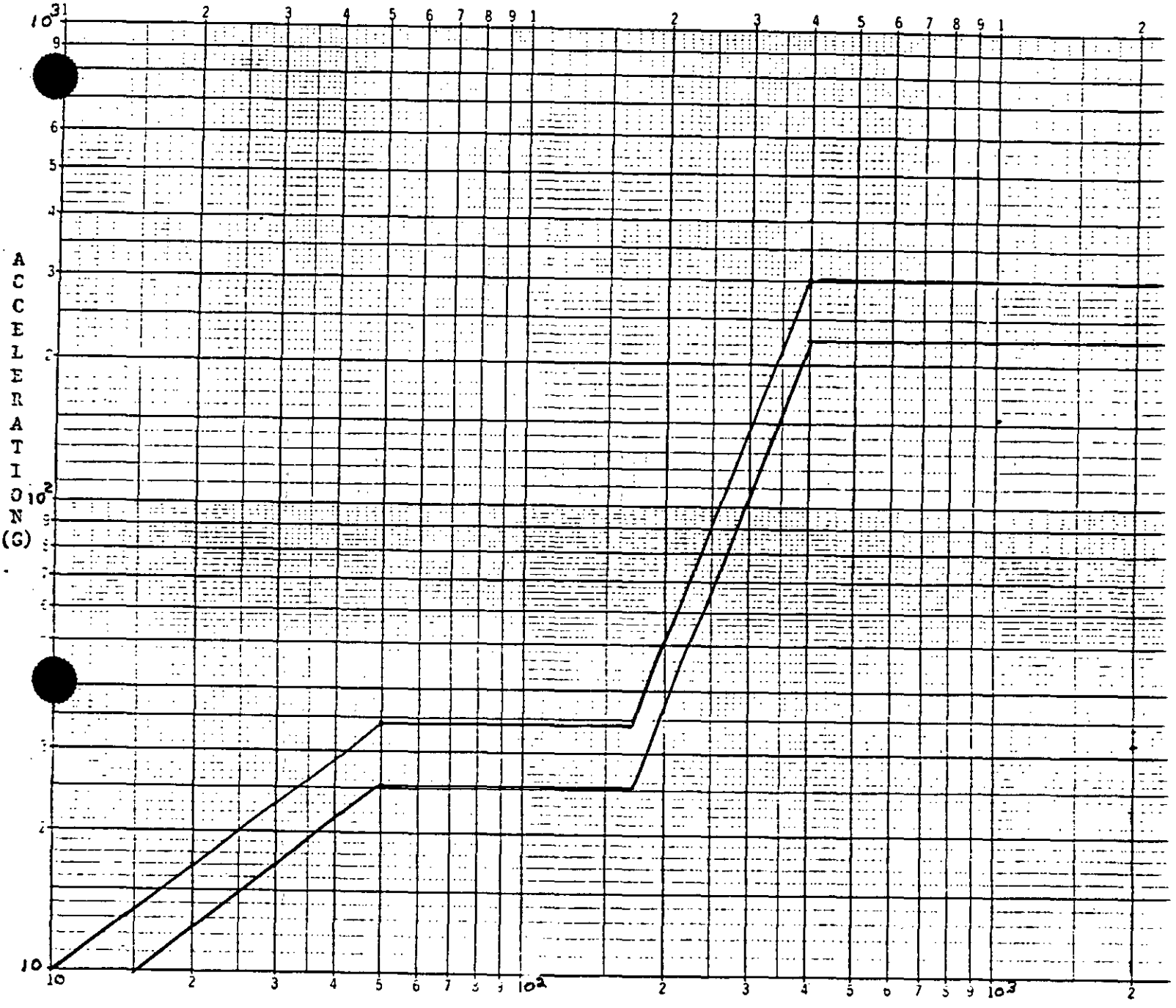
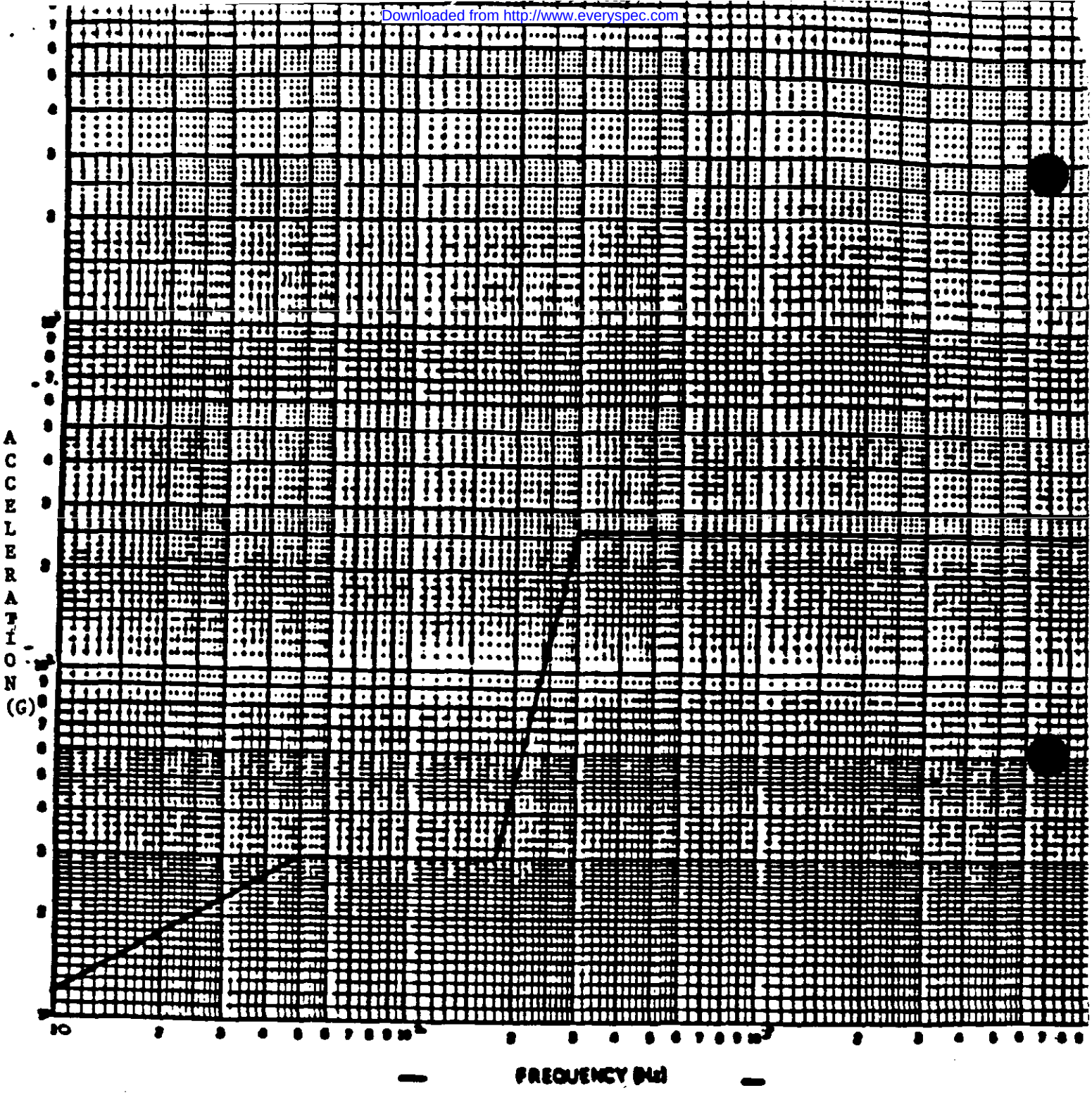


FIGURE 22 CHAMBER TEST CYCLE



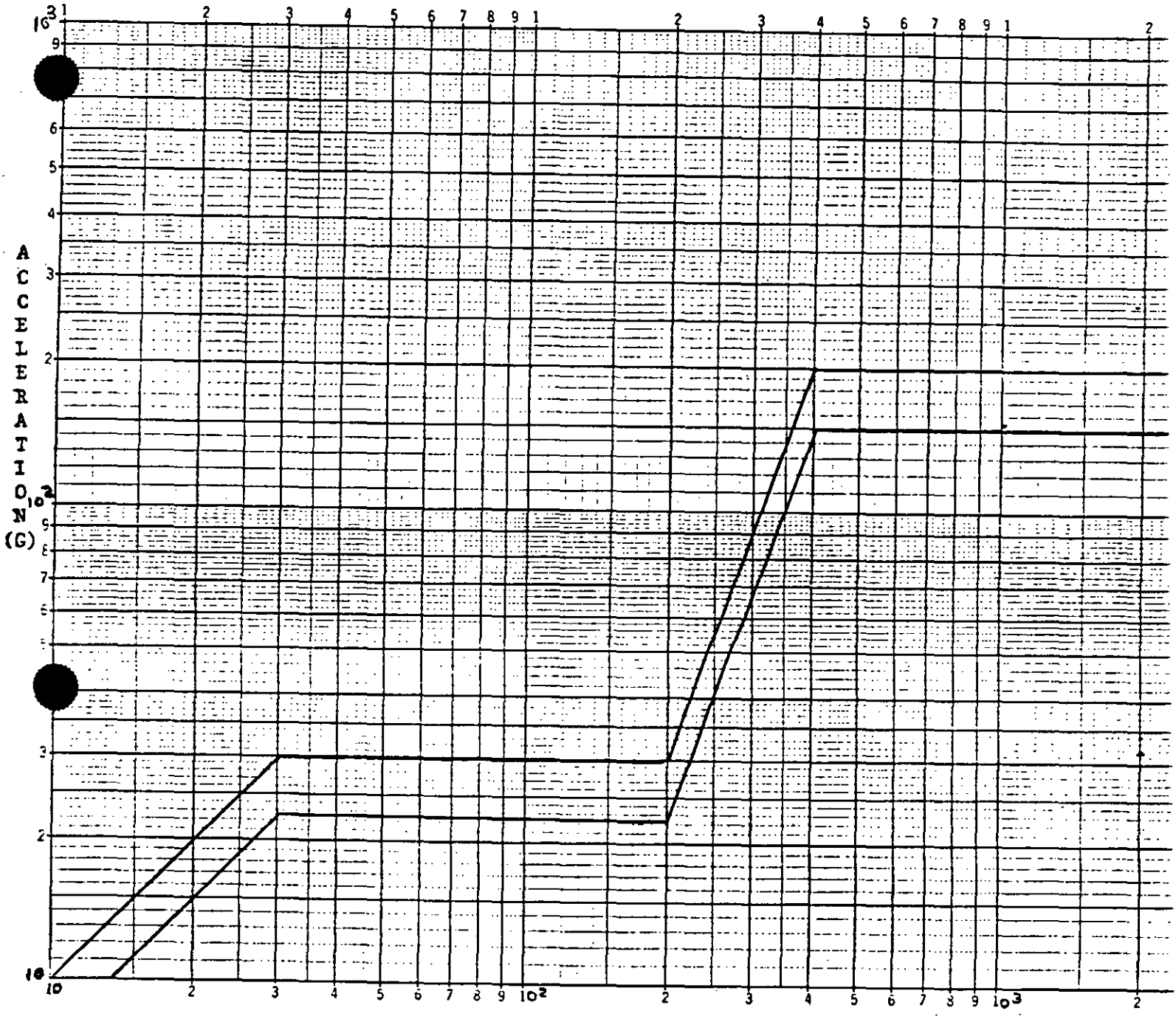
GUNFIRING SHOCK SPECTRUM - VERTICAL

FIGURE 23



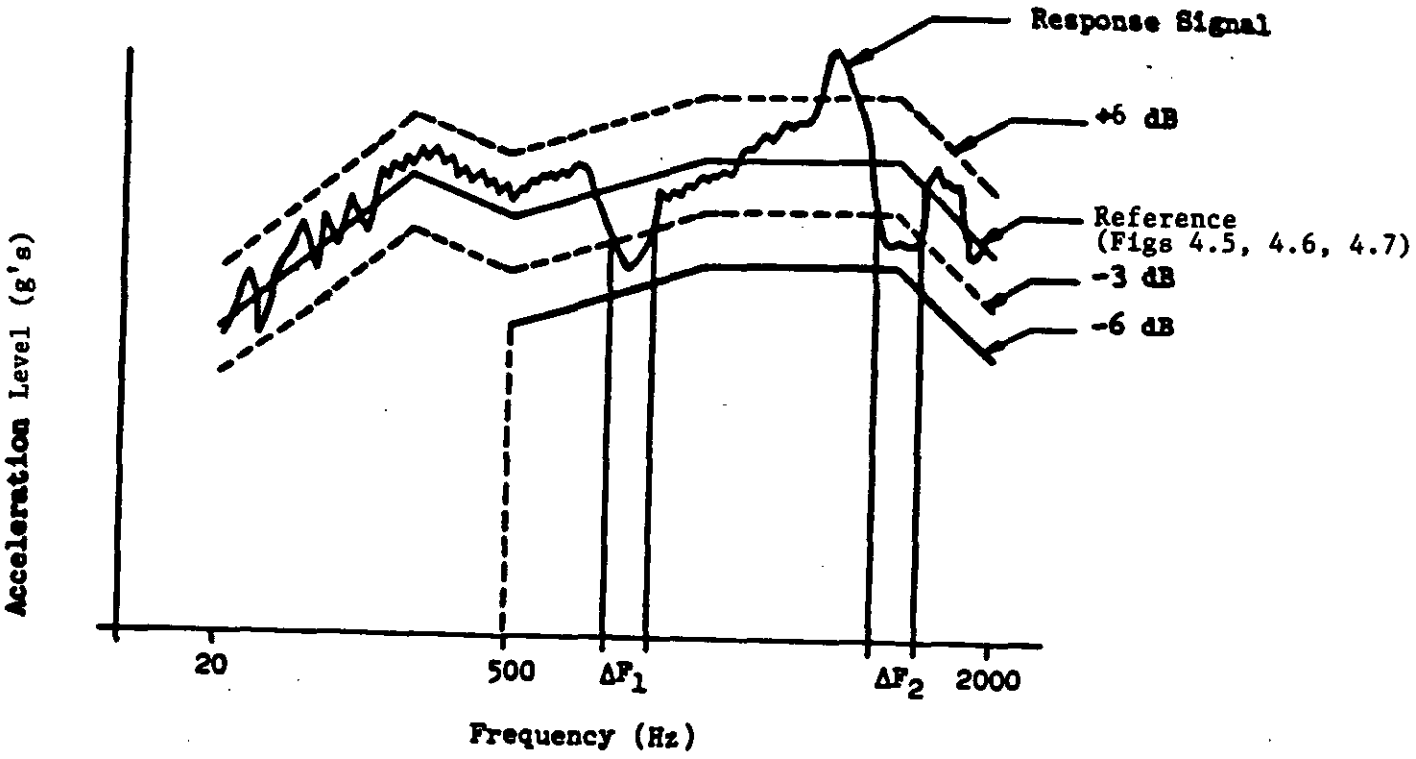
GUN FIRING SHOCK SPECTRUM - LATERAL

FIGURE 24



GUNFIRING SHOCK SPECTRUM - LONGITUDINAL

FIGURE 25



$\Sigma \Delta F_1 \leq 5\%$ of Test BW

FIGURE 26 Gun Firing Shock Tolerances

The acceleration power spectral density of the test control signal shall not deviate from the specific requirements more than permitted in Section II, Method 514.3 of MIL-STD-810.

4.8.6.2.2.2 Functional survey test. The DRU shall be used in Configuration A, Figure 1, for the functional survey test. The test conditions and procedures to be used are as follows:

a. Test Conditions.

(1) The DRU system will be operated in a ground vehicle over a government approved test course.
(2) One functional survey test will be run in an eight hour period.
(3) The DRU system shall stop no more than once every hour for a planned zero-velocity update. The system shall not be realigned more frequently than once every two hours.
(4) The distance traveled per run shall be approximately 63 miles (100 km).
(5) The test course shall have 11 known survey points, including starting point, approximately 6.3 miles (10 km) apart.

b. Test Procedure. The functional survey test will follow the procedure as outlined below:

(1) Install system in vehicle.
(2) Warm up, initialize, and align system at starting point (15 min.).
(3) Take test data at each survey point.
(4) Turn off system and remove from vehicle.

The test data must meet accuracies as specified in 3.6.

4.8.6.2.2.2.1 Statistical performance criteria. The following sets of data shall meet the statistical criteria established for survey parameters (3.6.1.1.1 through 3.6.1.1.7):

a. All accumulated data. (Initialization point excluded)

b. At least 98 percent of the individual missions containing 10 or more survey control points. All data obtained in an individual mission shall be used to compute that mission's statistics. (Initialization point excluded)

c. All the individual survey control points at which 20 or more measurements were made using essentially the same mission trajectory. Only errors exceeding the maximum (99 percent) individual error limits may be excluded from these calculations. (Alignment accuracy at the initialization point shall be included).

4.8.6.2.3 Failure criteria and definition.

4.8.6.2.3.1 Equipment failure definition. The term failure is defined as any malfunction which causes or may cause the system to be inoperable or to:

a. Fail to commence operation, cessation of operation or degradation of performance below designated levels.

b. Damage to the system if operation is continued.

c. Results in personnel or equipment safety hazards.

A pattern failure is defined as two or more occurrences of the same failure.

Malfunctions that require corrective action will be charged as a failure against the DRU. The following are counted as equipment failures:

a. A malfunction detected or corrected during the correction of another failure, provided the failures are totally unrelated.

b. Actual or incipient malfunctions detected during technical inspection at termination of test.

c. Failure to meet any accuracies specified.

d. Spurious BIT indicators (3.10).

The following malfunctions are not considered to be equipment failures:

a. Malfunctions caused by improper operational procedures.

b. Malfunctions caused by abuse, unspecified operating conditions, or accidents.

c. Malfunctions resulting from failure of the vehicle or other associated equipment unless it is determined that the DRU contributed to the malfunction.

4.8.6.2.3.2 Action taken in event of an equipment failure. When a failure occurs, or whenever it becomes evident that the DRU will not meet a specified requirement, or will not pass a test, the testing shall be stopped. Failure action as defined in MIL-STD-781 shall be followed and augmented as follows. Occurrence of a pattern failure or design or software induced failure shall be a reject condition. When a reject condition has been reached, the contractor shall submit a plan for corrective action, validation of corrective action, and resumption of reliability testing for government approval.

4.8.6.3 Maintainability. Maintenance operations required during the Reliability Demonstration specified in 4.8.6.2 shall be accomplished to determine conformance to 3.6.4. In the event that the maintenance operations performed are insufficient to quantitatively assess the corrective maintenance specified in 3.6.4.1, the government shall perform or simulate additional maintenance tasks as required to complete the assessment. Failure to maintain the DRU as specified in 3.6.4 shall constitute failure of this test.

4.8.6.4 Performance demonstration. The government may test the DRU for compliance to any of the criteria and characteristics as specified in 3.5, 3.6, 3.8 and 3.10, including accuracy at high latitudes and tolerance to gun firing shock. Actual or simulated installation conditions, environments, and operational scenarios may be used. Failure of the DRU to perform as specified shall constitute failure of the test.

4.8.7 Design verification. The DRU shall be tested to verify conformance to the design requirements specified in 3.5, 3.6, 3.8 and 3.10. The design characteristics to be verified shall include, but not be limited to, the following:

a. Alignment characteristics (3.5.3.1 through 3.5.3.4). Normal Align gyrocompassing tests over the specified operating temperatures with the DRU oriented at each of the cardinal headings. The DRU shall be turned off for 1 hour between gyrocompasses for tests performed at -50°F at each of the cardinal headings.

b. Zero-velocity characteristics (3.5.3.2.1.1 through 3.5.3.2.1.3).

c. Insensitivity to odometer calibration and alignment of DRU case to direction of travel (3.5.3.2.1.4).

d. Power source sensitivity, protection, and power consumption (3.5.4.2).

e. Power control characteristics (3.5.4.2.1).

f. Output power characteristics (3.5.4.2.2).

g. Signal circuit characteristics (3.5.4.4.1 through 3.5.4.4.1.1).

h. Data Bus, command and message characteristics (3.5.4.4.2 through 3.5.4.4.3.1, 3.5.4.4.3.5).

i. Acceptance and response to commands (3.5.4.4.3.2, 3.5.4.4.3.4, Appendices A, B, and C).

j. Message characteristics (3.5.4.4.3.3, 3.5.4.4.3.4, Appendices D and E).

k. Travel Lock Discrete characteristics (3.5.4.5).

l. Odometer interface characteristics (3.5.4.6).

m. Travel lock determination, shot detect, dynamic motion correction, and related Status and Alerts (3.5.5, 3.5.6).

n. Position update characteristics (3.5.7).

o. Configuration data (3.5.8).

p. Angular rate accuracy (3.6.1.1.8).

q. Sensitivity to off level alignment conditions (3.6.1.4.1).

r. Operation when pitched 90° (3.6.1.5.2.b).

s. Interchangeability (3.8.5).

t. Built-In-Test accuracy, characteristics, and data checking (3.10 through 3.10.6.2).

Failure to meet any specified requirement shall constitute failure of the test.

4.8.8 Nuclear hardness validation.

4.8.8.1 Tests and analyses. Tests and analyses shall be performed on the equipment in its intended operating configuration to assure the system nuclear survivability as specified in 3.8.2. Specific areas of consideration are discussed in 4.8.8.2 thru 4.8.8.5 inclusive.

Calibration certification of the facilities to be used are required by the Contracting Officers Technical Representative (COTR), 45 days prior to the nuclear test. Verification of the wave shape of the test simulator is required. Calibration and wave shape verification shall be supplied to the COTR by the contractor.

Simulation tests that do not reproduce all the required parameters of any stated environment must be extended through analysis to indicate the significance of that test and its relation to the threat environment.

4.8.8.2 Electromagnetic pulse (EMP). The equipment in its intended deployment configuration(s) and operational modes, which are worst case for the nuclear EMP environments, shall be exposed at the specified threat levels. Ground-based systems and equipment shall be tested within the irradiation volume of an appropriate radiated-wave, ground-effect EMP simulator (e.g., the Harry Diamond Laboratories' Army EMP Simulator Operations (AESOP)). Placement of the system equipment within the simulator test volume must ensure for worst-case EMP coupling (i.e., by maximum allowable separation of the system equipment, and maximum extension of the system interconnecting cables paralleled to the electric field and perpendicular to the magnetic field). Current injection tests are necessary to verify the functionality of and hardness margin afforded by the protection devices employed at the equipment signal and power interfaces.

The equipment shall be exposed at threat level in the above orientations and in each operating mode of the equipment. The equipment shall meet the operational requirements of 3, upon completion of threat level tests. Where approved by the government, test data to satisfy the EMP requirements may be obtained by extrapolation of diagnostic test levels to threat level and current injection pulsing at the calculated level.

4.8.8.3 Initial nuclear radiation. For the purpose of design, but not validation testing, optical components, electronic pieceparts, and circuits for which nuclear test data are available, or for which an acceptable level of confidence has been established through mathematical analysis need not be subjected to further nuclear design testing. Acceptance of these optical components, electronic pieceparts, circuits and mathematical analysis will be determined by the procuring agency from data or analyses supplied to the government by the contractor. Nuclear survivability at the specified temperature extremes will be demonstrated by appropriate analysis and tests or, where acceptable, by analysis alone. The assembled equipment shall be tested for hardness to exposure to neutron fluence, total dose, and peak gamma dose rate.

4.8.8.3.1 Neutron fluence. The equipment shall be exposed in such a manner that all optical components, electronic pieceparts and circuits receive the specified Neutron Fluence. The equipment shall be energized, if appropriate to examine worst case response. The equipment shall perform as specified in 3.

4.8.8.3.2 Total dose. The equipment shall be exposed in such a manner that all optical components, electronic pieceparts, and circuits receive the Total Dose specified. The equipment shall be energized during exposure and shall then perform as specified in 3. Except for the fiber optics and n-channel metal-oxide semiconductor (NMOS), verification of device hardness against permanent damage from gamma ray dose may be achieved by the gamma output which normally accompanies the Neutron Fluence. Gamma dose hardness of fiber optics and NMOS devices must be verified by Cobalt-60 irradiation in which the Total Dose specified is delivered in a steady-state exposure on the order of 20 seconds duration.

4.8.8.3.3 Peak gamma dose rate. The equipment shall be exposed in such a manner that all optical components, electronic pieceparts, and circuits receive the Peak Gamma Dose specified. The equipment shall be energized during exposure and shall then perform as specified in 3.

4.8.8.4 Thermal radiation. The equipment in its intended deployment configuration(s), which are worst case(s) for the nuclear thermal and air-blast environments, shall be subjected to thermal radiation tests at appropriate thermal radiation levels over the entire exposed surface(s) of the equipment. In instances where only thermal radiation facilities that can be used provide these specified levels over only relatively small areas of the equipments surfaces, individual exposures will be required for each of the candidate surface and outboarded items (e.g., case, meters, knobs, antennas, cables) to ensure the thermal radiation survivability of the equipment. In such instances, thermal radiation tests of selected material samples (of the surfaces and items) may be appropriate. Following the thermal radiation tests, the equipment shall then meet the performance requirements stipulated in Section 3.

4.8.8.5 Nuclear air-blast. The equipment in its intended deployment configuration(s) which are worst case(s) for nuclear thermal and air-blast environments, shall be subjected to air-blast tests at the appropriate air-blast simulation facilities that provide the specified air-blast levels. The equipment air-blast sensitivity(ies) as determined through appropriate analyses, drive the selection of the simulation environments to be used. The selected air-blast simulator(s) must be capable of providing the specified air-blast threat environment characteristic(s) needed to demonstrate equipment compliance in meeting air-blast requirements. For equipment which is housed within an enclosure, the equipment must survive the induced shocks and accelerations that are transmitted through the enclosure when the enclosure is subjected to the specified nuclear air-blast environments. In both instances, for equipment exposed directly to the air-blast environment and for equipment protected within an enclosure, the equipment shall meet the operational requirements of Section 3 following the air-blast test.

Tests or analysis shall be performed to account for synergistic effects of thermal radiation received before the Nuclear Air-Blast.

5. PACKAGING

5.1 Packaging, packing, and marking. Packaging, packing, and marking shall be in accordance with MIL-P-14232 and Packaging Data Sheet. The level of protection shall be as specified in the procurement document.

6. NOTES

6.1 Intended use. These self contained inertial surveying systems are designed to be used on weapon and target systems.

6.2 Ordering data. Procurement data should specify the following:

a. Title, number and date of this specification. Issue of DODISS specifying issues of referenced specifications or listing of specific issues of referenced documents.

b. Selection of an applicable level of preservation, packaging, and packing.

c. Applicable packaging data sheet number (See 5.1).

d. Applicable stock number.

e. Provisions for First Article Testing.

f. Reliability Assurance Sample.

g. Contract data requirements for submission of inspection equipment designs conforming to Data Item Description DI-R-1714.

h. Provisions for the sample size of the performance demonstration of the qualification test.

6.3 First article. When a first article inspection is required, the items should be first article samples. The first article should consist of five units. The contracting officer should include specific instructions in acquisition documents regarding arrangements for examinations, approval of first article test results and disposition of first articles. Invitations for bids should provide that the Government reserves the right to waive the requirement for samples for first article inspection to those bidders offering a product which has been previously acquired or tested by the Government, and that bidders offering such products, who wish to rely on such production or test, must furnish evidence with the bid that prior Government approval is presently appropriate for the pending contract.

6.4 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time set for opening of bids, qualified for inclusion in the Qualified Products List (QPL) for the Dynamic Reference Unit whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. The activity responsible for the Qualified Products List is ARDEC, SMCAR-BAC-S, Picatinny Arsenal, NJ 07806-5000 and information pertaining to the qualification of products may be obtained from that activity.

6.5 Inspection equipment design.

6.5.1 Submission of designs for approval. Contactor designs for final acceptance inspection shall be approved by the Government prior to fabrication or procuring the equipment. The contractor is referred to MIL-HDBK-204 for guidance. Submission of design concept

on inspection equipment is permissable for tentative approval. The completion date for design review will be based on the date of the final submission of designs and the required delivery schedule as stipulated in the contract. Submit designs as required to: Commander, U.S. Army Armament, Research, Development and Engineering Center, AMSMC-QAF-I (D), Picatinny Arsenal, NJ 07806-5000. This address will be specified on the Contract Data Requirements List DD Form 1423 in the contract. Unless otherwise specified, data item DI-R-1714 will apply. When the contractor submits inspection equipment designs to the government for approval, he shall give the following information in his letter of transmittal:

a. The contract number.

b. The contract item (name, model number, etc.).

c. The designs remaining to be submitted and the expected date of submittal.

6.6 Coordinate and reference frames.

6.6.1 Position.

6.6.1.1 UTM Position. Horizontal position in the Universal Transverse Mercator (UTM) coordinate system is defined by the hemisphere, numerical grid zone, Easting and Northing in accordance with TM 5-241-8, Universal Transverse Mercator Grid. The UTM coordinates can be referenced to several different spheroids.

6.6.1.2 Hemisphere (DRU). The DRU Hemisphere is the hemisphere where the DRU presently is located. It is input at the start of a mission. During the mission, the DRU must keep track of the hemisphere for the present location and output it when requested.

6.6.1.3 Universal transverse mercator (UTM) grid zone. UTM grid zone is the numerical designation for the zone in which the DRU is located. The numerical designation of the zone input at the start of a mission may represent the normal zone or the extended zone, depending on the coordinates available. When output is requested, the numerical designation of the zone in a message may represent the normal zone or the extended zone, depending on the coordinates associated with the zone. When normal zone or extended zone boundaries are crossed, the DRU will automatically change the numerical designation for the zone in output messages to that of the normal zone in which it is located.

6.6.1.4 Extended zone boundaries. The boundaries for extended UTM zones are:

$$\emptyset E = \pm 100{,}000 / R_e$$

$$\lambda E = \lambda Z \pm 100{,}000/[R_e \times \cos(\emptyset)]$$

Where:

$\emptyset E$ = Geographic Latitude of Extended Zone Boundary (radians)

R_e = Elopsoidal Radius of the Earth (meters)

λE = Geographic Longitude of Extended Zone Boundary (radians)

λZ = Geographic Longitude of the Normal Zone Boundary (radians)

$\emptyset$ = Geographic Latitude of the DRU (radians)

6.6.1.5 Spheroids. A spheroid code number, either in memory or input via the ACCEPT POSITION command during Normal Align, indicates which spheroid parameters are to be used by the DRU to compute coordinates and grid convergence. During a mission, the spheroid code number can only be changed after a Restart. When output is requested, the DRU repeats the last value input. The parameters of the following reference spheroids shall be selected by entering the corresponding code number:

CODE NO.	SPHEROID	SEMI-MAJOR AXIS (Meters)	INVERSE FLATTENING
0	Airy	6377563	299.3250
1	Clark 1866	6378206	294.97870
2	International (Hayford 1909)	6378388	297.0
3	Clark 1880	6378249	293.46630
4	Everest 1830	6377276	300.80170
5	Bessel 1841	6377397	299.150
6	Spare	6378137	298.257235630
7	Spare	6378137	298.257235630
8	GRS 1967	6378160	298.250
9	GRS 80/WGS 84	6378137	298.257235630
10	Airy	6377563	299.3250
11	Modified Airy	6377340	299.3250
12	Modified Everest	6377304	300.8010
13	WGS 1972	6378135	298.260
14	Hough	6378270	297.0
15	Indicates no change to presently selected spheroid.		

When spheroid code No. 0 is selected, the DRU will operate in the British National Grid on the Airy spheroid.

6.6.1.6 British National Grid. The British National Grid has only one zone in the northern hemisphere. The zone is given the numerical designation of zero in output messages. It is assumed that the zone boundaries are never crossed. The British National Grid is defined in the Ordnance Survey Information Leaflet, No. 72, March 1983.

6.6.2 Altitude. Altitude is the distance between the present DRU position and the reference geoid (an equipotential surface of the earth approximated by mean sea level) measured along the local gravity vector (normal to the geoid). Altitude is positive when the DRU is above the geoid and negative when below. The DRU will accept starting and update altitudes for its present position. When requested, the DRU will output its present altitude.

6.6.3 Orientation. DRU orientation is defined by the relationship of the DRU case coordinate frame to an earth referenced coordinate frame. An intermediate DRU coordinate frame relates the case coordinate frame to the DRU mounting orientation. A suitable DRU coordinate frame and set of boresight angles should be selected for each installation to insure proper definition of orientation parameters during pointing device deployment (DRU rotation).

6.6.3.1 DRU reference frames.

6.6.3.1.1 Case coordinate frames. The DRU case reference frame is a set of right hand orthogonal axes, $\overline{X}_C$, $\overline{Y}_C$, $\overline{Z}_C$, shown in Figure 27. The origin is located where the center axis of alignment hole R, labeled DATUM axis V in Figure 9 intersects the precision mounting surface, DATUM plane G-U, Figure 10. Axis $\overline{X}_C$ is along the intersection of the DATUM plane G-U and Section A-A, Figure 10, which passes thru the centers of alignment holes R and D. Axis $\overline{Y}_C$ coincides with DATUM axis V in Figure 9. The axis $\overline{Z}_C$ is along the intersection of DATUM plane G-U and DATUM plane Z, Figure 9, which passes through the center of the mounting holes.

6.6.3.1.2 DRU coordinate frame. The DRU coordinate frame is an intermediate set of right hand orthogonal axes, $\overline{X}_D$, $\overline{Y}_D$, $\overline{Z}_D$, as shown in Figure 28a. The case coordinate frame is related to the DRU coordinate frame by the unit rotation matrix [R]. Elements of the rotation matrix, r_{ij}, may have the values -1, 0, 1. Examples are shown in Figures 28b and 28c.

6.6.3.2 Earth reference coordinate frame. The earth reference coordinate frame is an orthogonal coordinate set ($\overline{X}_E$, $\overline{Y}_E$, $\overline{Z}_E$). $\overline{X}_E$ points to: grid north, $\overline{Y}_E$ to grid east, and $\overline{Z}_E$ downward along the local vertical. Grid north equals geodetic north plus the grid convergence as described in TM 5-241-8, Universal Transverse Mercator Grid, and the Ordnance Survey Information Leaflet, No 72, March 1983. When operating in the extended zone, grid convergence is calculated in terms of its present position in the extended zone, hemisphere, and reference spheroid.

6.6.3.3 Orientation parameters. The DRU orientation parameters are defined in terms of rotations between the earth reference, intermediate, and DRU coordinate frames as shown in Figure 29.

6.6.3.3.1 DRU Grid Azimuth. Grid Azimuth is the horizontal angle between grid north and the vertical projection of $\overline{X}_D$ onto the horizontal plane. Grid azimuth is measured clockwise from grid north and is always positive. DRU Grid Azimuth is calculated in terms of the present DRU Hemisphere, Zone, Position, and reference spheroid.

6.6.3.3.2 DRU pitch. Pitch is the vertical angle between the vertical projection of $\overline{X}_D$ onto the horizontal plane and $\overline{X}_D$. Pitch is positive when $\overline{X}_D$ lies above the horizontal plane and negative when below.

6.6.3.3.3 DRU roll. Roll is the angle between the horizontal plane and $\overline{Y}_D$, measured in the $\overline{Y}_D$, $\overline{Z}_D$ plane. Roll is positive when $\overline{Y}_D$ lies below the horizontal plane and negative when above.

6.6.3.3.4 Vehicle boresight angles. A set of vehicle boresight angles, α, β, γ relates the DRU coordinate frame to the transporting vehicle's coordinate frame. α is the horizontal angle between the vehicle longitudinal axis and the vertical projection of $\overline{X}_D$ onto the horizontal plane when the vehicle longitudinal axis and cross axis are level. α is measured clockwise from the vehicle longitudinal axis direction of travel and is always positive. β is the vertical angle between the vertical projection of $\overline{X}_D$ onto the horizontal plane and $\overline{X}_D$ when the vehicle longitudinal axis and cross axis are level. β is positive when $\overline{X}_D$ lies above the horizontal plane and negative when below. γ is the angle between the horizontal plane and $\overline{Y}_D$ measured in the $\overline{Y}_D$, $\overline{Z}_D$ plane when the vehicle longitudinal axis and cross axis are level. γ is positive when $\overline{Y}_D$ lies below the horizontal plane and negative when above. α may have any value from 0 to +6399.9 mils. β may have any value from -1200 to +1200 mils. γ may have any value from -3199.9 to +3200.0 mils. When the DRU is installed on a pointing device, the vehicle boresight angles are the angles when the pointing device is stowed for vehicle travel.

The vehicle boresight angles are nominal values because variations may occur with prime system manufacturing tolerances, with different weight distribution in the vehicle, with vehicle turning and crabbing, and inexact repositioning when a pointing device is raised and then lowered.

6.6.3.3.5 Software case boresight angles to pointing device. A set of pointing device boresight angles, **A**, **B**, Γ, relates the DRU coordinate frame to that of the pointing device. **A** is the horizontal angle between the axis of the pointing device and the vertical projection of $\overline{X}_D$ onto the horizontal plane when the axis of the pointing device and its cross axis are level. **A** is measured clockwise from the direction of pointing and is always positive. **B** is the vertical angle between the vertical projection of $\overline{X}_D$ onto the horizontal plane and $\overline{X}_D$ when the axis of the pointing device and its cross axis are level. **B** is positive when $\overline{X}_D$ lies above the horizontal plane and negative below. Γ is the angle between the horizontal plane and $\overline{Y}_D$ measured in the $\overline{Y}_D$, $\overline{Z}_D$ plane when the axis of the pointing device and its cross axis are level. Γ is positive when $\overline{Y}_D$ lies below the horizontal plane and negative when above. **A** may have any value from 0 to +6399.9 mils. **B** may have any value from -1600.0 to +1600.0 mils. Γ may have any value from -3199.9 to +3200.0 mils.

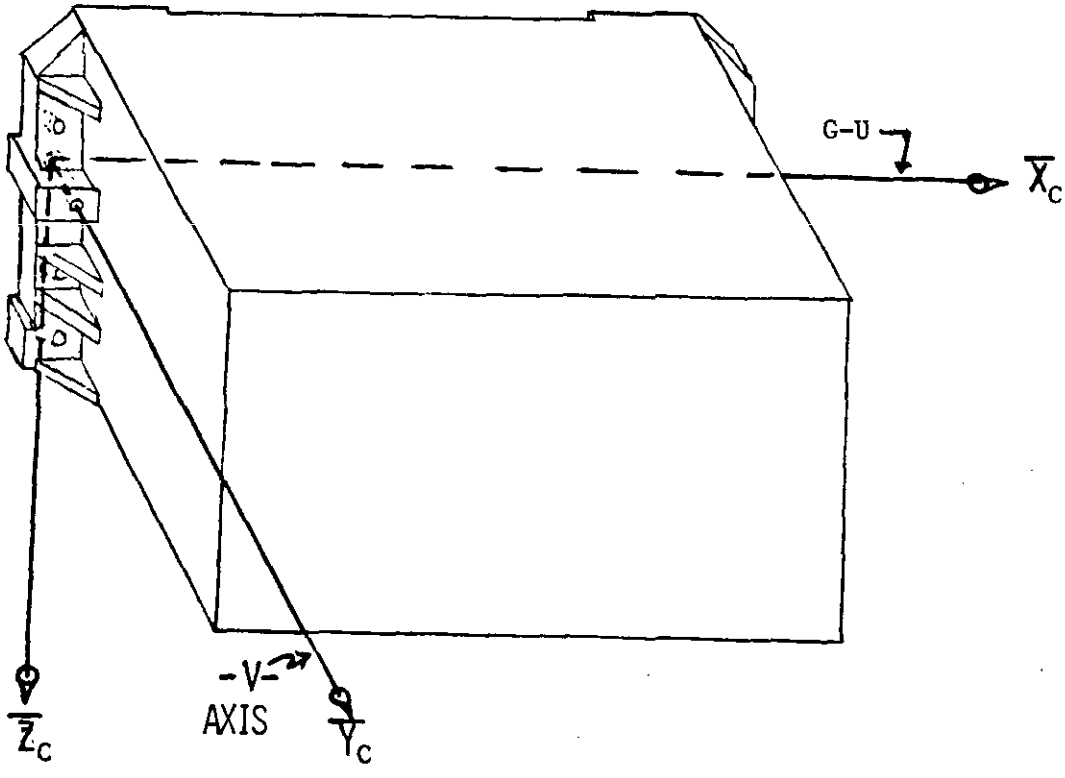
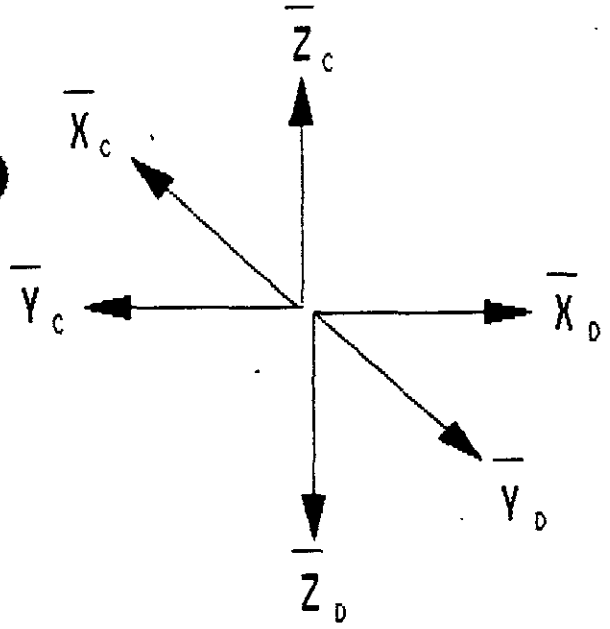


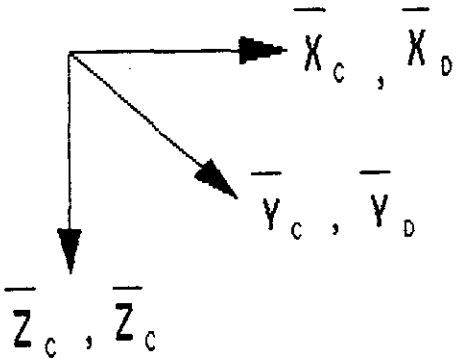
Figure 27 : DRU Case Reference Frames



$$\begin{bmatrix} \bar{X}_D \\ \bar{Y}_D \\ \bar{Z}_D \end{bmatrix} = \begin{bmatrix} R \end{bmatrix} \begin{bmatrix} \bar{X}_C \\ \bar{Y}_C \\ \bar{Z}_C \end{bmatrix}$$

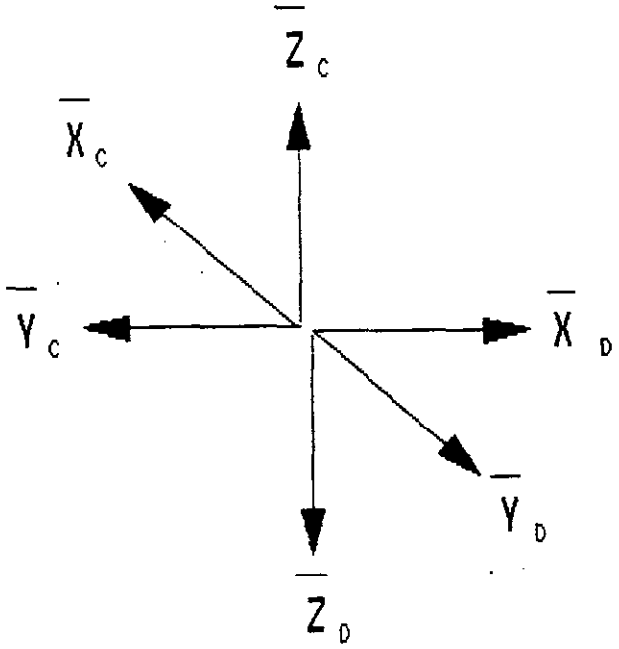
$$[R] = \begin{bmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{bmatrix}$$

a. Case to DRU Coordinate Frame Relationship



$$[R] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

b. Coincident Frames



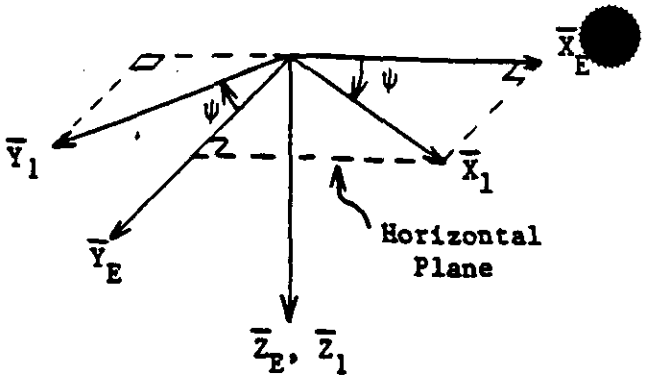
$$[R] = \begin{bmatrix} 0 & -1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & -1 \end{bmatrix}$$

c. Non-Coincident Frames

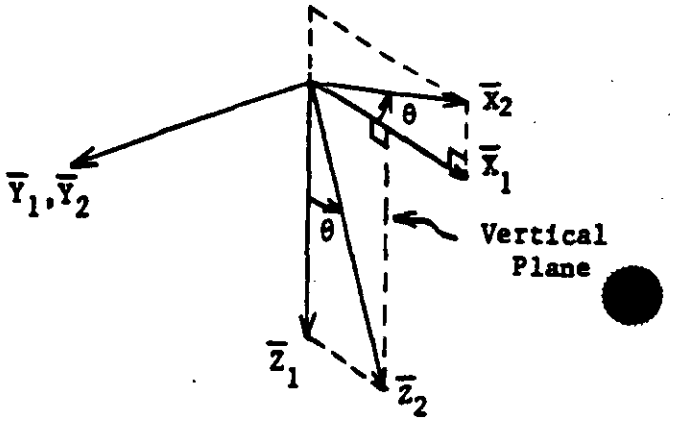
Figure 28

$$\begin{bmatrix} \bar{X}_D \\ \bar{Y}_D \\ \bar{Z}_D \end{bmatrix} = \Phi * \Theta * \Psi \begin{bmatrix} \bar{X}_E \\ \bar{Y}_E \\ \bar{Z}_E \end{bmatrix}$$

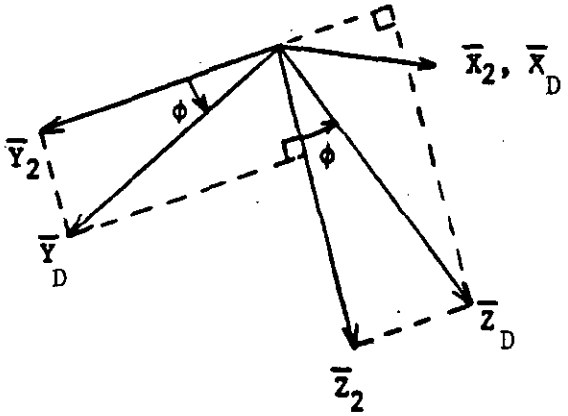
$$\Psi = \begin{bmatrix} \text{Cos } \psi & \text{Sin } \psi & 0 \\ -\text{Sin } \psi & \text{Cos } \psi & 0 \\ 0 & 0 & 1 \end{bmatrix}$$



$$\Theta = \begin{bmatrix} \text{Cos } \theta & 0 & -\text{Sin } \theta \\ 0 & 1 & 0 \\ \text{Sin } \theta & 0 & \text{Cos } \theta \end{bmatrix}$$



$$\Phi = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \text{Cos } \phi & \text{Sin } \phi \\ 0 & -\text{Sin } \phi & \text{Cos } \phi \end{bmatrix}$$



where:

ψ = Azimuth

θ = Pitch

ϕ = Roll

FIGURE 29

ORIENTATION PARAMETER DEFINITION

6.7 Orientation parameters.

6.7.1 Pointing Device Geodetic or Grid Azimuth. Pointing Device Geodetic or Grid Azimuth is the geodetic or grid azimuth of the axis of the pointing device in the direction of pointing and is the horizontal angle between geodetic or grid north and the vertical projection of the axis on the horizontal plane. Pointing Device Geodetic or Grid Azimuth is measured clockwise from geodetic or grid north and is always positive. It is permissible for Pointing Device Geodetic or Grid Azimuth to be in error when the pointing device pointing axis is nearly vertical.

6.7.2 Pointing Device Pitch. Pointing Device Pitch is the vertical angle between the projection of the axis of the pointing device on the horizontal plane and the axis. Pointing Device Pitch is positive when the axis in the direction of the pointing lies above the horizontal plane and negative when below.

6.7.3 Pointing Device Cant. Pointing Device Cant is the vertical angle between the pointing device cross axis immediately clockwise from the direction of the pointing and the projection of that cross axis on the horizontal plane. Pointing Device Cant is positive when the cross axis lies below the horizontal plane and negative when above.

6.7.4 Vehicle Geodetic or Grid Azimuth. Vehicle Geodetic or Grid Azimuth is the geodetic or grid azimuth of the longitudinal axis of the vehicle in the direction of travel and is the horizontal angle between geodetic or grid north and the vertical projection of the longitudinal axis on the horizontal plane. Vehicle Geodetic or Grid Azimuth is measured clockwise from geodetic or grid north and is always positive. On receipt of an OUT OF TRAVEL LOCK command or discrete and until receipt of an IN TRAVEL LOCK command or discrete, Vehicle Geodetic or Grid Azimuth is frozen and equals the last value prior to receipt of the OUT OF TRAVEL LOCK command or discrete.

6.7.5 Vehicle Pitch. Vehicle Pitch is the vertical angle between the projection of the longitudinal axis of the vehicle on the horizontal plane and the axis. Vehicle Pitch is positive when the axis direction of travel lies above the horizontal plane and negative when below. On receipt of an OUT OF TRAVEL LOCK command or discrete and until receipt of an IN TRAVEL LOCK command or discrete, Vehicle Pitch is frozen and equals the last value prior to receipt of the OUT OF TRAVEL LOCK command or discrete.

6.7.6 Vehicle Roll. Vehicle Roll is the angle between the horizontal plane and the vehicle cross axis immediately clockwise from the direction of travel measured in a plane normal to the vehicle longitudinal axis. Vehicle Roll is positive when the cross axis lies below the horizontal plane and negative when above. On receipt of an OUT OF TRAVEL LOCK command or discrete and until receipt of an IN TRAVEL LOCK command, Vehicle Roll is frozen and equals the last value prior to receipt of the OUT OF TRAVEL LOCK command or discrete.

6.7.7 Vehicle Cant. Vehicle Cant is the vertical angle between the vehicle cross axis immediately clockwise from the direction of travel and the projection of that cross axis on the horizontal plane. Vehicle Cant is positive when the cross axis lies below the horizontal plane and negative when above. Vehicle Cant = $\sin^{-1}$ [sin (Vehicle Roll) x cos (Vehicle Pitch)]. On receipt of an OUT OF TRAVEL LOCK command or discrete and until receipt of an IN TRAVEL LOCK command or discrete, Vehicle Cant is frozen and equals the last value prior to receipt of an OUT OF TRAVEL LOCK command or discrete.

6.7.8 Travel Lock Geodetic Azimuth or Grid Azimuth Reference. When the pointing device is in travel lock, Travel Lock Geodetic Azimuth or Grid Azimuth Reference equals the present Pointing Device Geodetic Azimuth or Grid Azimuth. In the case where the pointing device is a weapon, the reference is corrected for any vehicle chassis in motion resulting from weapon firing.

6.7.9 Travel Lock Pitch Reference. When the pointing device is in travel lock, Travel Lock Pitch Reference equals the present Pointing Device Pitch. In the case where the pointing device is a weapon, the reference is corrected for any vehicle chassis motion resulting from weapon firing.

6.8 Definitions.

6.8.1 Characteristics of NBC contamination survivability. NBC contamination survivability is the capability of a system and its crew to withstand an NBC-contaminated environment, including decontamination, without losing the ability to accomplish the assigned mission. Characteristics of NBC contamination survivability are decontaminability, hardness, and compatibility. To survive NBC contamination, material must meet criteria for all three.

6.8.1.1 Decontaminability. The ability of a system to be decontaminated to reduce the hazard to personnel operating, maintaining, and resupplying it is termed "decontaminability." Key to this definition is the requirement to be able to reduce the hazard to personnel. Since the principal benefit of decontamination is to allow the crew to reduce its level of protection, decontaminability criteria must be related to the response of unprotected personnel. NBC contaminants could eventually breach the shield of the protective ensemble. Therefore, when operations permit, the contaminants should be removed where they present a hazard. Further, decontamination reduces the soldier's vulnerability when the shield is dropped to satisfy basic physiological needs or to replace components of the NBC protective ensemble. Decontamination procedures are described in FM 3-5.

6.8.1.2 Hardness. The ability of a system to withstand the damaging effects of NBC contamination and any decontamination agents and procedures required to decontaminate it is termed "hardness." Although strongly related to decontaminability, hardness is a distinct characteristic; decontaminability refers to reducing the hazard to personnel as a result of decontamination efforts, while hardness refers to the condition of the equipment after it has been subjected to an agent decontamination.

6.8.1.3 Compatibility. The ability of a system to be operated, maintained, and resupplied by personnel wearing the full NBC protective ensemble is termed "compatibility." Even if a piece of equipment is completely hardened against NBC contamination and decontaminants and can also be easily decontaminated, it still must have the capability of being operated effectively while in an NBC contaminated environment.

6.8.1.4 Mission oriented protective posture; Level 4 (MOPP4). MOPP4 is a flexible system of protection against chemical agents which is used in chemical warfare to facilitate mission accomplishment. The soldier is required to wear individual protective equipment consistent with chemical threat. Level four requires the following protective equipment: fatigues, chemical protective overgarment or liner ensemble, protective mask, hood, gloves, overboots, and body armor. Use of this equipment is discussed in FM 3-4.

6.8.2 Error parameters.

6.8.2.1 Circular error probable (CEP). CEP is the radius of a circle, centered about true, such that any measured position, selected from the total sample population, has a 50 percent probability of lying inside the circle. CEP shall be computed as follows:

$$CEP = 1.1774 \quad \frac{RMS_n + RMS_e}{2}$$

Where: RMS_n and RMS_e are the RMS errors in Northing and Easting, respectively.

6.8.2.2 Radial error. Radial error is the linear difference in horizontal position between the measured reference values for a single position measurement.

$$\text{Radial Error} = [(m_e - M_e)^2 + (m_n - M_n)^2]^{1/2}$$

Where: m_e and m_n are the measured Easting and Northing, respectively.

M_e and M_n are the reference Easting and Northing, respectively.

6.8.2.3 RMS error. RMS error is the square root of the mean of the sum of the squared errors, relative to the reference value(s), for all measurements in the sample population. RMS error shall be computed as follows:

$$RMS_x = \left[\frac{\sum_{i=1}^{i=N} (X_i)^2}{N} \right]^{1/2}$$

Where:

N is the total number of measurements in the sample.
X_i is the error in the i'th measurement with respect to the reference value.

$X_i = m_i - M_i$ for linear or angular errors.

$X_i = 100\ m_i - M_i$ for percentage of distance traveled errors.

$\overline{S_i - S_o}$

$$X_i = \frac{(m_i - M_i) - (m_o - M_o)}{T_i - T_o} \text{ for drift errors.}$$

m_i is the i'th measurement in the sample. (m_o is the initial measurement)

M_i is the reference value associated with the i'th measurement.

$S_i - S_o$ is the odometer distance traveled since the last position update.

$T_i - T_o$ is the travel time since the last alignment or realignment.

6.8.2.4 Probable error (PE). PE is the equally likely deviation (50% probability) of a set of linear measurements about the true (reference) value. PE shall be computed as:

$$PE = 0.6745 \times RMS_x$$

6.8.2.5 Standard deviation about the mean. The Standard Deviation about the Mean (σ) is the measurement of the dispersion of the measurements in a sample about the arithmetic mean. σ shall be computed as:

$$\sigma = \left[\frac{\sum_{i=1}^{i=N} (m_i - \bar{m})^2}{N-1} \right]^{1/2}$$

Where: N is the total number of measurements in the sample.
m_i is the i'th measurement in the sample.
$\bar{m}$ is the arithmetic mean of the sample.

$$\bar{m} = \frac{\sum_{i=1}^{i=N} m_i}{N}$$

6.9 Abbreviations.

A	Ampere
AFCS	Automatic Fire Control System
ac	Alternating current
AM	Amplitude modulation
AGPS	Automatic Gun Positioning System
BCU	Battery Computer Unit
BIT	Built-In-Test
BTU	British Thermal Unit
C	Centigrade
CDU	Control and Display Unit
CCITT	International Telegraph and Telephone Consultative Committee
CEP	Circular Error Probable
Cm	Centimeter
COTR	Contracting Officer's Technical Representative
CRC	Cyclic Redundancy Check
CUCV	Commercial Utility Cargo Vehicle
CW	Continuous wave
dB	Decibels
DC	Direct current
DRU	Dynamic Reference Unit
E-field	Electrostatic field
EIA	Electronic Industries Association
EMI	Electromagnetic interference
EMP	Electromagnetic pulse
F	Fahrenheit
FM	Frequency modulation
fps	Feet per second
ft	Feet
g	Gram
g	Gravity
GHZ	Gigahertz
hr	Hour
Hz	Hertz
in	Inch
K	One thousand
KA	Kiloampere
Kg	Kilogram
Km	Kilometer
KV	Kilovolt
Lat	Latitude
lbs	Pounds
LSB	Least Significant Bit
m	Meter
M	Mil

ma	Milliampere
MHz	Megahertz
msec	Millisecond
min	Minutes
MMD	Mass median diameter
mm	Millimeter
mps	Meters per second
MSB	Most Significant Bit
MTBF	Mean-Time-Between-Failure
MTTR	Mean-Time-To-Repair
mv	Millivolt
Mv	Megavolt
N	North
NBC	Nuclear-Biological-Chemical
NMOS	N-Channel metal-oxide semiconductor
NRZ	Non-return to zero
PE	Probable Error
pf	Picofarad
pk-pk	Peak-to-peak
PSCD	Prime System Control Display
RMS	Root mean square
RTN	Return
S	South
SCC	Serial Communication Controller
SDLC	Synchronous Data Link Control
sec	Second
T	Time
TBD	To be Determined
UTM	Universal Transverse Mercator
V	Volts
VMS	Vehicle Motion Sensor
W	Watt

6.10 Subject term (key word) listing.

Fire Control
MAPS
Navigation
Positioning system

DRU APPENDICES

DYNAMIC REFERENCE UNIT APPENDICES

10. SCOPE

10.1 Scope. These appendices detail the commands that transfer data from the prime system or CDU to the DRU, from the DRU to the prime system or CDU and commands that do not transfer data but cause a mode or operator change, definition of Data Messages and description of STATUS Characters. They also contain the vibration test schedules. These appendices are a mandatory part of this specification. The information herein is intended for compliance.

20. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

30. COMMANDS

APPENDIX A

COMMANDS THAT TRANSFER DATA FROM THE PRIME SYSTEM OR CDU TO THE DRU

30.1 Commands that transfer data from the prime system and/or CDU to the DRU.

30.1.1 Command: ACCEPT POSITION (NAVIGATION UPDATE)

From: Prime System To: DRU

Function: This user update command requests the DRU to accept the transmission of position (navigation) data from the prime system. The DRU accepts update data when the DRU is stationary.

If criteria for acceptance of data entry have been met, the DRU shall accept updates in any one of the following groupings and conditions:

When operating in the Universal Transverse Mercator Grid:

a. Hemisphere, zone, spheroid, northing, easting, and altitude, either in terms of the normal zone or extended zone, but only during initialization or restart.

b. Hemisphere, zone, northing, easting, and altitude, either in terms of the normal zone or extended zone.

c. Hemisphere, zone, northing, and easting, either in terms of the normal zone or extending zone.

d. Altitude only.

e. Designation of normal zone or extended zone for output messages.

When operating in the British National Grid:

f. Spheroid, northing, easting, and altitude in terms of the British National Grid, but only during initialization or restart.

g. Northing, easting, and altitude in terms of the British National Grid.

h. Northing and easting in terms of the British National Grid.

i. Altitude only.

DRU Response: STATUS DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	00101	D1 - D11	16 Bits	01111110

Number of Data Characters: 11.

Data Format: Binary 2's Complement

D1, D2, D3 Characters (24 bits) — Northing
Range: 0 to 10^7 meters
Resolution: 1 meter

D4, D5 Characters (15 bits) — Altitude
Range: -9,999 to +9,999 meters
Resolution: 1 meter

D6 Character (7 bits) — Extended Zone Hemisphere & Zone or set +0 for Normal Zone
Range: ± 60 (Integer)

+ indicates northern hemisphere; -, southern

D7 Character (7 bits) — Hemisphere & Zone of DRU
Range: ± 60 (Integer)
+ indicates northern hemisphere; -, southern

D8 Character (most significant 4 bits) — Set to 0
Range:

D8 Character (least significant 4 bits) — Prime System Spheroid
Range: 1 to 15 (Integer)

D9, D10, D11 Characters (20 bits) — Easting
Range: 0 to 999,999 meters
Resolution: 1 meter

30.1.2 Command: ACCEPT BORESIGHT

From: Prime System To: DRU

Function: This command enters pointing device boresight angles between the DRU mounting plate and prime system device being pointed. Use of this command is valid only when the boresight flag in configuration data is set.

DRU Response: STATUS DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	10111	D1 - D6	16 Bits	01111110

Number of Data Characters: 6

Data Format: Binary 2's Complement

D1, D2 Characters (16 bits) **A** as defined in 6.6.3.3.5
Range: 0 to 6399.9 Mils
Resolution: 0.1 Mil

D3, D4 Characters (16 bits) **B** as defined in 6.6.3.3.5
Range: -1600.0 to +1600.0 Mils
Resoloution: 0.1 Mil

D5, D6 Characters (16 bits) **Γ** as defined in 6.6.3.3.5
Range: -3199.9 to +3200.0 Mils
Resolution: 0.1 Mil

30.1.3 Command: ACCEPT CONFIGURATION DATA

From: Prime System To: DRU

Function: This command provides the DRU the data defined in 3.5.8.1 and other data desired by each supplier to optimize performance as a function of an installation/vehicle type.

DRU Response: STATUS DATA MESSAGE

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	00011	D1 - D33	16 Bits	01111110

Number of Data Characters: 33

Data Format: Binary 2's Complement except for D23, D24 and D31 - 33 which are binary, and D27-D30, which is floating point.

D1, D2 Characters (16 bits) Range: 0 to 6399.9 mils Resolution: 0.1 mil		α, defined in 6.6.3.3.4
D3, D4 Characters (16 bits) Range: -1600.0 to +1600.0 mils Resolution: 0.1 mil		β, defined in 6.6.3.3.4
D5, D6 Characters (16 bits) Range: -3199.9 to +3200.00 mils Resolution: 0.1 mil		γ, defined in 6.6.3.3.4
D7, through D12	Spare Characters	Set to 0
D13 Character (8 bits) Range: -9.9 to +9.9 meters Resolution: 0.1 meter		ΔX, offset along the vehicle longitudinal axis (3.5.8.3)
D14 Character (7 bits) Range: -4.9 to +4.9 meters Resolution: 0.1 meter		ΔY, offset along the vehicle across axis (3.5.8.3)
D15 Character (7 bits) Range: -4.9 to +4.9 meters Resolution: 0.1 meter		ΔZ, offset along the vehicle vertical axis (3.5.8.3)
D16 Character (6 bits) Range: 2 to 15 minutes Resolution: .25 minute		ZUPT interval for ZUPT mode
D17 Character (6 bits) Range: 2 to 63 minutes Resolution: 1 minute		ZUPT interval for Odometer mode

D18 Character (8 bits) Range: 3.5 to 63.75 minutes Resolution: 0.25 minute	Normal Align Time
D19 Character (5 bits) Range: 1.0 to 7.75 minutes Resolution: 0.25 minute	Stored Heading Align Time
D20 Character (5 bits) Range: 1.0 to 7.75 minutes Resolution: 0.25 minute	Realign Time
D21 through D22 Spare Characters	Set to 0
D23, D24 Characters (16 bits binary)	Configuration definition flag (3.5.8.8)
D25, D26 Characters (11 bits) Range: 0.750 to 1.250 Resolution: 0.001	VMS Scale Factor Calibration
D27 - D30 Characters (32 bits) Type: MIL-STD-1750A Floating Point Units: Radians/meter	Fuel Consumption Factor
D31 through D33 Characters (binary)	DRU Coordinate Frame Rotation Matrix [R]

[R] MATRIX ELEMENTS

Char/Bits	0, 1	2, 3	4, 5	6, 7
D31	r_{11}	r_{12}	r_{13}	00
D32	r_{21}	r_{22}	r_{23}	00
D33	r_{31}	r_{32}	r_{33}	00

Element Values
0 = 00 (binary)
1 = 01 (binary)
-1 = 11 (binary)

CONFIGURATION DEFINITION FLAGS

FLAG CHAR/BIT	SET FUNCTION	RESET FUNCTION
D23/0	Output Geodetic Azimuth	Output Grid Azimuth
1	Output Vehicle Roll	Output Vehicle Cant
2	Spare	
3	Spare	
4	Spare	
5	Spare	
6	Spare	
7	Spare	
D24/0	Odometer Mode	Exclusive ZUPT Mode
1	Spare	
2	Tracked Vehicle	Wheeled Vehicle
3	Use Travel Lock Discrete	Ignore Travel Lock Discrete
4	Use Travel Lock commands	Ignore Travel Lock commands
5	Use Shot Detect Processing	Don't Use Shot Detect Processing
6	Spare	
7	Use Boresight Angles	Ignore Boresight Angles

Reset spares to "0".

APPENDIX B

COMMANDS THAT REQUEST TRANSFER OF DATA FROM THE DRU TO THE PRIME SYSTEM OR CDU

30.2 Commands that Request Transfer of Data from the DRU to the Prime System and/or CDU.

30.2.1 Command: RETURN DRU RATE DATA

From: Prime System To: DRU

Functions: This command requests the DRU to transmit current angular rates to the prime system.

DRU Response: DRU RATE DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	01101	NONE	16 Bits	01111110

30.2.2 Command: RETURN CONFIGURATION DATA

From: Prime System To: DRU

Function: This command requests the DRU to transmit the configuration data presently used by the DRU to the prime system.

DRU Response: CONFIGURATION DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	10100	D1	16 Bits	01111110

Number of Data Characters: 1

Data Format: D1 Binary

D1 Character (8 bits) Command Subcode

Value: 7

30.2.3 Command: RETURN STATUS

From: Prime System To: DRU

Function: This command asks the DRU to transmit current STATUS to the prime system.

DRU Response: STATUS DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	10000	NONE	16 Bits	01111110

30.2.4 Command: RETURN NAVIGATION DATA

From: Prime System To: DRU

Function This data request command asks the DRU to transmit current navigation data consisting of: position, attitude, hemisphere, zone, spheroid, distance traveled, pointing device geodetic or grid azimuth, and vehicle attitudes to the prime system.

DRU Response: NAVIGATION DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	10001	NONE	16 Bits	01111110

30.2.5 Command: RETURN ATTITUDE DATA

From: Prime System To: DRU

Function: This command requests the DRU to transmit current attitude data to the prime system.

DRU Response: ATTITUDE DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	00001	NONE	16 Bits	01111110

30.2.6 Command: RETURN ALIGN TIME TO GO

From: Prime System To: DRU

Function: This data request command asks the DRU to transmit the amount of time remaining until Normal Align, Stored Heading Align or Realign is complete.

DRU Response: ALIGN TIME TO GO Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	10010	NONE	16 Bits	01111110

30.2.7 Command: RETURN ALERT DATA

From: Prime System To: DRU

Function: This data request command asks the DRU to transmit to the prime system, Alert Data that indicates a problem or error.

DRU Response: ALERT DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	10011	NONE	16 Bits	01111110

30.2.8 Command: RETURN BIT DATA

From: Prime System To: DRU

Function: This command asks the DRU to transmit Built-in-Test (BIT) data to the prime system.

DRU Response: BUILT-IN-TEST DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	11111	NONE	16 Bits	01111110

30.2.9 Command: RETURN TRAVEL LOCK DATA

From: Prime System To: DRU

Function: This command asks the DRU for travel lock data.

DRU Response: TRAVEL LOCK DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	00000	NONE	16 Bits	01111110

30.2.10 Command: RETURN POSITION DATA

From: Prime System To: DRU

Function: This data request command asks the DRU to transmit current position data consisting of Spheroid, Hemisphere, Zone, Easting, Northing and Altitude to the prime system.

DRU Response: POSITION DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	01001	NONE	16 Bits	01111110

30.2.11 Command: RETURN DRU ORIENTATION AND POINTING DEVICE DATA

From: Prime System To: DRU

Function: This command requests the DRU to transmit current DRU Orientation and Pointing Device Data to the prime system.

DRU Response: DRU ORIENTATION DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	01100	NONE	16 Bits	01111110

30.2.12 COMMAND: ASSIGNED TO SUPPLIERS

Command code 6 (00110) may be used by each Contractor.

The Suppliers shall assign identifier Code 12 to the message associated with Command Code 6.

30.2.13 Command: RETURN BORESIGHT

From: Prime System To: DRU

Function: This command requests the DRU to transmit the pointing device boresight angles to the prime system.

DRU Response: BORESIGHT ANGLES Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	10100	D1	16 Bits	01111110

Number of Data Characters: 1

Data Format: D1 Binary

D1 Character (8 bits) Command Subcode

Value: 8

30.2.14 Command: RETURN EXPANDED STATUS

From: Prime System To: DRU

Function: This command requests the DRU to transmit the EXPANDED STATUS message.

DRU Response: EXPANDED STATUS DATA message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	10100	D1	16 Bits	01111110

Number of Data Characters: 1

Data Format: D1 Binary

D1 Character (8 bits) Commmand Subcode

Value: 9

30.2.15 Command: RETURN SURVEY QUALITY

From: Prime System To: DRU

Function: This command requests the DRU to transmit the SURVEY QUALITY message.

DRU Response: SURVEY QUALITY message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	10100	D1	16 Bits	01111110

Number of Data Characters: 1

Data Format: D1 Binary

D1 Character (8 bits) Commmand Subcode

Value: 10

APPENDIX C

COMMANDS THAT DON'T TRANSFER DATA BUT CAUSE A MODE OR OPERATION CHANGE

30.3 DRU Mode Change Command Messages (NO DATA TRANSFER).

30.3.1 Command: OVERRIDE ALERT

From: Prime System To: DRU

Function: The OVERRIDE ALERT command is sent by the Prime System/CDU to clear overridable alert indications.

DRU Response: STATUS DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	01000	NONE	16 Bits	01111110

30.3.2 Command: RESET DISTANCE

From: Prime System To: DRU

Function: This user update command requests the DRU to reset to zero the total accummulated distance traveled by the vehicle.

DRU Response: STATUS DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	00111	NONE	16 Bits	01111110

30.3.3 Command: RESTART

From: Prime System To: DRU

Function: The purpose of the RESTART command is to allow the operator the capability of commanding Normal Align and to correct update data without cycling DRU input power.

Upon receipt of this mode change command the DRU shall reinitialize and perform Normal Align. The DRU may be commanded to restart while in any mode, but shall respond only if the DRU is not moving.

DRU Response: STATUS DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	11010	NONE	16 Bits	01111110

30.3.4 Deleted.

30.3.5 Deleted.

30.3.6 Command: INHIBIT AUXILIARY BUS CONTROL

From: Prime System To: DRU

Function: This command inhibits auxiliary bus control if the command is received on the Main Bus. The Auxiliary Bus control STATUS bit is set. The Auxiliary Bus responds only to commands that transfer data from the DRU when the Auxiliary Bus is inhibited. If an illegal command is attempted, bit 1 in ALERT DATA character D5 will be set. When inhibited, the Auxiliary Bus will respond to the following commands only:

a. RETURN TRAVEL LOCK DATA.
b. RETURN ATTITUDE DATA.
c. RETURN GUN LEVEL DATA.
d. RETURN STATUS.
e. RETURN NAVIGATION DATA.
f. RETURN ALIGN TIME TO GO.
g. RETURN ALERT DATA.
h. RETURN BIT DATA.
i. RETURN DRU RATE DATA.
j. RETURN POSITION DATA.
k. RETURN DRU ORIENTATION and POINTING DEVICE DATA.
l. RETURN CONFIGURATION DATA.
m. RETURN MESSAGE IN RESPONSE TO COMMAND ASSIGNED TO SUPPLIERS.
n. RETURN BORESIGHT.

DRU Response: STATUS DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	01010	NONE	16 Bits	01111110

30.3.7 Command: ENABLE AUXILIARY BUS CONTROL

From: Prime System To: DRU

Function: If this command is received on the Main Bus, the Auxiliary Bus control is enabled and the Auxiliary Bus control STATUS bit is reset. This command permits the Auxiliary Bus to respond to all commands except INHIBIT AUXILIARY BUS CONTROL and ENABLE AUXILIARY BUS CONTROL. If the operator attempts to execute either of these commands, the invalid mode request, bit 6 of ALERT DATA character D5 is set.

DRU Response: STATUS DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	01011	NONE	16 Bits	01111110

30.3.8 Command: STORED HEADING ALIGN

From: Prime System To: DRU

Function: The operator may select the Stored Heading Align mode rather than allowing the DRU to automatically sequence through Normal Align. The Stored Heading Align mode will allow the DRU to be ready for survey within 1 minute of the command. Valid stored data must be available to the DRU to enter and successfully complete Stored Heading Align.

DRU Response: STATUS DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	11011	NONE	16 Bits	01111110

30.3.9 Command: REALIGN

From: Prime System To: DRU

Function: With the DRU stationary and in the Survey mode the DRU can be commanded to Realign. In REALIGN the DRU shall rapidly restore system alignment accuracy to that of the initial alignment.

At completion of Realign the DRU shall automatically return to the Survey mode. If the DRU is not in the Survey mode when a REALIGN Command is received, an "Invalid Mode Request" alert shall be generated.

DRU Response: STATUS DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	11100	NONE	16 Bits	01111110

30.3.10 Command: SHUTDOWN

From: Prime System To: DRU

Function: This command requests the DRU to store position data in a non volatile memory before power is removed. Alert bit 7 of character D3 shall be set and the request ignored if the vehicle is moving when the command is received. ALERT bit 0 of character D2 shall be set if the vehicle is moving while the SHUTDOWN command is being processed.

Current position, azimuth, pitch and roll, and any other data which are necessary to resume normal operation when power is turned on, shall be stored prior to removing power. If power control is enabled the SHUTDOWN Command also shall cause the DRU to be deenergized. The time to complete storage of data shall not exceed 4.5 sec beginning with receipt of the first bit of the command.

DRU Response: STATUS DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	11110	NONE	16 Bits	01111110

30.3.11 Command: OUT OF TRAVEL LOCK

From: Prime System To: DRU

Function: This command tells the DRU that the pointing device is about to leave travel lock.

DRU Response: STATUS DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	10100	D1	16 Bits	01111110

Number of Data Characters: 1

Data Format: D1 Binary

D1 Character (8 bits) Command Subcode

Value: 6

30.3.12 Command: INHIBIT ZERO-VELOCITY UPDATES

From: Prime System To: DRU

Function: This command shall inhibit zero-velocity updates. The command may be used during laboratory evaluation of attitude and position drift under static conditions. The inhibit command together with the enable command (30.3.13) may be used in vehicles that move very slowly during part of a mission.

DRU Response: STATUS DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	01111	NONE	16 Bits	01111110

30.3.13 Command: ENABLE ZERO-VELOCITY UPDATES

From: Prime System To: DRU

Function: This command shall enable zero-velocity updates. The command may be used during laboratory evaluation of attitude and position drift under static conditions. The enable command together with the inhibit command (30.3.12) may be used on vehicles that move very slowly during part of a mission. Upon turn-on, the DRU automatically shall enable zero-velocity updates.

DRU Response: STATUS DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	10101	NONE	16 Bits	01111110

30.3.14 Command: IN TRAVEL LOCK

From: Prime System To DRU

Function: The purpose of this command is to allow the operator to designate the travel lock status. The pointing device will be in travel lock when this command is initiated.

DRU Response: STATUS DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	10100	D1	16 Bits	01111110

Number of Data Characters: 1

Data Format: D1 Binary

D1 Character (8 bits) Command Subcode

Value: 5

30.3.15 Command: ZUPT MODE REQUEST

From: Prime System To: DRU

Function: This command allows the operator to change the DRU mode of operation from odometer aided to periodic zero-velocity updates.

DRU Response: STATUS DATA MESSAGE

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	10100	D1	16 Bits	01111110

Number of Data Characters: 1

Data Format: D1 Binary

D1 Character (8 bits) Command Subcode

Value: 1

30.3.16 Command: ODOMETER MODE REQUEST

From: Prime System To: DRU

Function: This command allows the operator to change the DRU mode of operation from periodic zero velocity updates to odometer aided. Under certain conditions the DRU will not comply with the request (3.5.3.2.1.2, 3.5.3.2.1.3).

DRU Response: STATUS DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	10100	D1	16 Bits	01111110

Number of Data Characters: 1

Data Format: D1 Binary

D1 Character (8 bits)

Value: 2

30.3.17 Command: FIX ALTITUDE

From: Prime System To: DRU

Function: This commad instructs the DRU, when operating in the ZUPT mode, to hold altitude constant. This will prevent excessive altitude error growth during ferry and swimming operations where it is not possible to ZUPT at the required intervals. Normally the FIX ALTITUDE command will be used in conjunction with the ZUPT MODE REQUEST and INHIBIT ZERO-VELOCITY UPDATES commands.

DRU Response: STATUS DATA MESSAGE

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	10100	D1	16 Bits	01111110

Number of Data Characters: 1

Data Format: D1 Binary

D1 Character (8 bits) Command Subcode

Value: 3

30.3.18 Command: RELEASE ALTITUDE

From: Prime System To: DRU

Function: This command cancels the FIX ALTITUDE command. It instructs the DRU to measure altitude. The RELEASE ALTITUDE command normally will be used in conjunction with the ENABLE ZERO-VELOCITY UPDATES and ODOMETER MODE REQUEST commands.

DRU Response: STATUS DATA Message

COMMAND STRUCTURE

FLAG(F)	SEQUENCE NUMBER(N)	COMMAND CODE(C)	DATA CHARACTERS(D)	ERROR DET. CODE CHARACTERS(E)	FLAG(F)
01111110	XXX	10100	D1	16 Bits	01111110

Number of Data Characters: 1
Data Format: D1 Binary
D1 Character (8 bits) Command Subcode
Value: 4

APPENDIX D

DEFINITION OF DATA MESSAGES

30.4 Definition of Data Messages.

30.4.1 Message: DRU RATE DATA

From: DRU To: Prime System

Number of Data Characters: 6

Data Format: Binary 2's Complement

MESSAGE STRUCTURE

FLAG(F)	ECHO SEQ#(N)	IDENTIFIER(I)	STATUS S1,S2	DATA(D)	ERROR DET. CODE (E)	FLAG(F)
01111110	XXX	01011	16 Bits	D1-D6	16 bits	01111110

The angular rate of DRU Azimuth, Pitch and Roll are contained in the six characters of the data.

D1, D2 Characters (16 bits) DRU Azimuth Rate
Range: -3276.7 to +3276.8 mils/second*
Resolution: 0.1 mil/second

D3, D4 Characters (16 bits) DRU Pitch Rate
Range: -3276.7 to +3276.8 mils/second*
Resolution: 0.1 mil/second

D5, D6 Characters (16 bits) DRU Roll Rate
Range: -3276.7 to +3276.8 mils/second*
Resolution: 0.1 mil/second

* For rates outside the data range, the value shall be fixed at +3276.8 for positive rates and -3276.7 for negative rates.

30.4.2 Message: CONFIGURATION DATA

From: DRU To: Prime System

Number of Data Characters: 33

Data Format: Binary 2's Complement except for D22-D24 and D31-33 which are binary, and D27-D30, which is floating point.

MESSAGE STRUCTURE

FLAG(F)	ECHO SEQ#(N)	IDENTIFIER(I)	STATUS S1,S2	DATA(D)	ERROR DET. CODE (E)	FLAG(F)
01111110	XXX	10010	16 Bits	D1-D33	16 bits	01111110

D1, D2 Characters (16 bits) — α, defined in 6.6.3.3.4
Range: 0 to 6399.9 mils
Resolution: 0.1 mil

D3, D4 Characters (16 bits) — β, defined in 6.6.3.3.4
Range: -1600 to +1600 mils
Resolution: 0.1 mil

D5, D6 Characters (16 bits) — γ, defined in 6.6.3.3.4
Range: -3199.9 to +3200.0
Resolution: 0.1 mil

D7, D8 Characters (16 bits) — A, defined in 6.6.3.3.5
Range: 0 to 6399.9 mils
Resolution: 0.1 mil

D9, D10 Characters (16 bits) — B, defined in 6.6.3.3.5
Range: -1600.0 to +1600.0 mils
Resolution: 0.1 mil

D11, D12 Characters (16 bits) — Γ, defined in 6.6.3.3.5
Range: -3199.9 to +3200.0 mils
Resolution: 0.1 mil

D13 Character (8 bits) — ΔX offset along the vehicle longitudinal axis (3.5.8.3)
Range: -9.9 to +9.9 meters
Resolution: 0.1 meter

D14 Character (7 bits) — ΔY offset along the vehicle cross axis (3.5.8.3)
Range: -4.9 to +4.9 meters
Resolution: 0.1 meter

D15 Character (7 bits) — ΔZ offset along the vehicle vertical axis (3.5.8.3)
Range: -4.9 to +4.9 meters
Resolution: 0.1 meter

D16 Character (6 bits) — ZUPT interval for ZUPT mode
Range: 2 to 15 minutes
Resolution: .25 minute

D17 Character (6 bits) Range: 2 to 63 minutes Resolution: 1 minute	ZUPT interval for Odometer mode
D18 Character (8 bits) Range: 3.5 to 63.75 minutes Resolution: 0.25 minutes	Normal Align Time
D19 Character (5 bits) Range: 1.0 to 7.75 minutes Resolution: 0.25 minute	Stored Heading Align Time
D20 Character (5 bits) Range: 1.0 to 7.75 minutes Resolution: 0.25 minute	Realign Time
D21 Spare Character	Set to 0
D22 Character (4 bits)	Discrete logic configuration code
D23, D24 Characters (16 bits binary)	Configuration definition flags (3.5.8.8)
D25, D26 Characters (11 bits) Range: 0.750 to 1.250 Resolution: 0.001	VMS Scale Factor Calibration
D27 - D30 Characters (32 bits) Type: MIL-STD-1750 Floating Point Units: radians/meter	Fuel Consumption Factor
D31 - 33 Characters (binary)	DRU Coordinate Frame Rotation Matrix [R]

[R] MATRIX ELEMENTS

Char/Bits	0, 1	2, 3	4, 5	6, 7	Elements Values
D31	r_{11}	r_{12}	r_{13}	00	0 = 00 (binary)
D32	r_{21}	r_{22}	r_{23}	00	1 = 01 (binary)
D33	r_{31}	r_{32}	r_{33}	00	-1 = 11 (binary)

CONFIGURATION DEFINITION Flags

FLAG CHAR/BIT	SET FUNCTION	RESET FUNCTION
D23/0	Output Geodetic Azimuth	Output Grid Azimuth
1	Output Vehicle Roll	Output Vehicle Cant
2	Spare	
3	Spare	
4	Spare	
5	Spare	
6	Spare	
7	Spare	
D24/0	Odometer Mode	Exclusive ZUPT Mode
1	Spare	
2	Tracked Vehicle	Wheeled Vehicle
3	Use Travel Lock Discrete	Ignore Travel Lock Discrete
4	Use Travel Lock commands	Ignore Travel Lock commands
5	Use Shot Detect Processing	Don't Use Shot Detect Processing
6	Spare	
7	Use Boresight Angles	Ignore Boresight Angles

30.4.3 Message: NAVIGATION DATA

From: DRU To: Prime System

Number of Data Characters: 22

Data Format: Binary 2's Complement

MESSAGE STRUCTURE

FLAG(F)	ECHO SEQ#(N)	IDENTIFIER(I)	STATUS S1,S2	DATA(D)	ERROR DET. CODE (E)	FLAG(F)
01111110	XXX	00001	16 Bits	D1-D22	16 bits	01111110

The 22 characters of this message contain easting, northing, altitude, distance traveled, pointing device geodetic or grid azimuth, vehicle attitudes, and DRU spheroid, hemisphere, and zone.

D1, D2, D3 Characters (24 bits) Range: 0 to 10^7 meters Resolution: 1 meter	Northing
D4, D5 Characters (15 bits) Range: -9,999 to +9,999 meters Resolution: 1 meter	Altitude
D6, D7, D8 Characters (17 bits) Range: 0 to 10^6 meters Resolution: 10 meters	Distance Traveled
D9, D10 Characters (16 bits) Range: 0 to 6,399.9 mils Resolution: 0.1 mil	Pointing Device Geodetic Azimuth or Grid Azimuth
D11, D12 Characters (15 bits) Range: -1000 mils to +1000 mils Resolution: 0.1 mil	Vehicle Cant or Roll
D13, D14 Characters (15 bits) Range: -1600 mils to +1600 mils Resolution: 0.1 mil	Vehicle Pitch
D15, D16 Characters (16 bits) Range: 0 to 6,399.9 mils Resolution: 0.1 mil	Vehicle Geodetic Azimuth or Grid Azimuth
D17 Character (most significant 4 bits) (least significant 4 bits) Range: 1 to 15 (Integer)	Set to 0 DRU Spheroid
D18, D19, D20 Characters (20 bits) Range: 0 to 10^6 meters Resolution: 1 meter	Easting
D21 Character (7 bits)	Set to 0
D22 Character (7 bits) Range: -60 to +60, + indicates northern hemisphere; -, southern	DRU Hemisphere & Zone

30.4.4 Message: ATTITUDE DATA

From: DRU To: Prime System

Number of Data Characters: 12

Data Format: Binary 2's Complement

MESSAGE STRUCTURE

FLAG(F)	ECHO SEQ#(N)	IDENTIFIER(I)	STATUS S1,S2	DATA(D)	ERROR DET. CODE (E)	FLAG(F)
01111110	XXX	00010	16 Bits	D1-D12	16 bits	01111110

This data represents Pointing Device geodetic or grid azimuth, Pointing Device Pitch with respect to local level, vehicle cant or roll, and Pointing Device azimuth and pitch rates.

D1, D2 Characters (16 bits) — Pointing Device Geodetic or Grid Azimuth
Range: 0 to 6,399.9 mils
Resolution: 0.1 mil

D3, D4 Characters (15 bits) — Pointing Device Pitch
Range: -1600 to +1600 mils
Resolution: 0.1 mil

D5, D6, Characters (15 bits) — Vehicle Cant or Roll
Range: -1000 mils to +1000 mils
Resolution: 0.1 mil

D7, D8 Characters (15 bits) — Vehicle Pitch
Range: -1600 mils to +1600 mils
Resolution: 0.1 mil

D9, D10 Characters (16 bits) — Pointing Device Azimuth Rate
Range: -360 to +360 mils/sec
Resolution: 0.18 mil/sec

D11, D12 Characters (16 bits) — Pointing Device Pitch Rate
Range: -180 to +180 mils/sec
Resolution: 0.18 mil/sec

30.4.5 Message: ALIGN TIME TO GO

From: DRU To: Prime System

Number of Data Characters: 2

Data Format: Binary

MESSAGE STRUCTURE

FLAG(F)	ECHO SEQ#(N)	IDENTIFIER(I)	STATUS S1,S2	DATA(D)	ERROR DET. CODE (E)	FLAG(F)
01111110	XXX	00111	16 Bits	D1-D2	16 bits	01111110

The two characters of this data represent the amount of time remaining until Normal Align is complete.

D1, D2 Characters (12 bits) Normal Align Time To Go
Range: 0 - 3825 seconds
Resolution: 1 second

30.4.6 Message: ALERT DATA

From: DRU To: Prime System

Number of Data Characters: 5

Data Format: Binary

MESSAGE STRUCTURE

FLAG(F)	ECHO SEQ#(N)	IDENTIFIER(I)	STATUS S1,S2	DATA(D)	ERROR DET. CODE (E)	FLAG(F)
01111110	XXX	00110	16 Bits	D1-D5	16 bits	01111110

The presence of a "1" in a bit position of this data signifies that a problem exists that requires operator action.

D1 Character

Bit Set	Problem
0	Previous Shutdown Abnormal. If the vehicle has moved since position and orientation data were last stored in non-volitle memory and the stored data has not been updated during subsequent shutdown; or if the vehicle is moving while position data is being stored during a nuclear event, processing of a SHUTDOWN command, or unintential loss of power; or if, for any other reason, the data is improperly stored or not stored at all during shutdown, then, the next time there is a power turn-on, this bit shall be set to alert the operator that the lost power shutdown was abnormal and that the stored data may be invalid.
1	Spare.
2	Sensor Over Temperature. DRU is too hot.
3	Realign Interrupt. The DRU/vehicle has moved during Realign.
4	Spare.
5	Spare.
6	Spare.
7	Spare.

D2 Character

Bit Set

0 Shutdown Interrupt. The vehicle is moving while a SHUTDOWN command is being processed.
1 Zero-Velocity Interrupt. During a mandated zero-velocity update, the vehicle must be stopped. If motion is detected this bit shall be set.
2 Position Update Interrupt. The vehicle starts moving while a position update command is being processed.
3 Align Interrupt. The DRU/vehicle has moved during Normal Align.
4 Align Terminated. Initial coordinate or instrument bias shift errors are too large to complete Normal Align.
5 Stored Heading No Good. The DRU has determined that the stored heading is not usable.
6 Align Initial Parameters, Not Received. Indicates the operator did not enter the initial parameters. DRU will align from previously stored data.
7 Spare.

D3 Character (Vehicle Motion)

Bit Set

0 Motion With Pointing Device Out of Travel Lock. Indicates the Pointing Device is not in the travel lock position when the vehicle is moving.
1 Excessive Rates. The vehicle dynamics have exceeded the DRU linear or angular rate capability and survey data may be in error. It shall not be reset until a Normal Align and position update have been performed.
2 Spare.
3 Spare.
Spare.
5 Motion During Position Update Request. DRU will not accept the request because vehicle is moving.
6 Motion During Restart/Realign Request. DRU will not accept the request because vehicle hasn't come to a full stop.
7 Motion During Shutdown Request. Same as above.

D4 Character, Data Update

Bit Set

0 Northing or Easting Update Excessive. This bit set indicates the magnitude of the update closure error exceeds 10 meters plus the DRU 3-sigma error estimate for Northing or Easting.

1 Altitude Update Excessive. This bit set indicates the magnitude of the closure error exceeds 5 meters plus the DRU 3-sigma altitude error estimate.
2 Spare.
3 Northing or Easting Update Rejected. During survey the DRU rejected this update because the magnitude of the closure error exceeded 150 meters plus the DRU 12-sigma error estimate for Northing or Easting. During Normal Align the DRU rejected this update because it is out of the allowable range.
4 Altitude Update Rejected. During Survey the DRU rejected this update because the magnitude of the closure error exceeded 50 meters plus the DRU 12-Sigma altitude error estimate. During Normal Align the DRU rejected this update because it is out of the allowable range.
5 Boundry Crossed. The DRU has crossed the equator or normal zone boundry or extended zone boundry.
6 DRU Hemisphere/Zone Change. Due to a position update the DRU hemisphere or zone was changed.
7 DRU Spheroid Change. Due to a position update during Normal Align the DRU Spheroid was changed from what was in storage.

D5 Character, Communication

Bit Set

0 Undefined Command Received. An unrecognized command has been received.
1 Invalid Command Received. An invalid command was received on the Auxiliary Data Bus.
2 Invalid Data Received. Data received was outside the allowable range.
3 Configuration Data Not Present. The DRU did not receive the configuration data or for an unknown reason the stored data was erased.
4 Boresight Angles Not Present. The DRU did not receive the boresight angles or for an unknown reason the stored data was erased.
5 Invalid Data Request. Data requested is not currently available.
6 Invalid Mode Request. DRU can recognize request but it cannot respond at this time.
7 Invalid Update Request. Attempt to enter update data when the DRU cannot accept it.

Note: Set spares to zero.

30.4.7 Message: BUILT-IN-TEST (BIT) DATA

From: DRU To: Prime System

Number of Data Characters: 2

Data Format: Binary

MESSAGE STRUCTURE

FLAG(F)	ECHO SEQ#(N)	IDENTIFIER(I)	STATUS S1,S2	DATA(D)	ERROR DET. CODE (E)	FLAG(F)
01111110	XXX	00100	16 Bits	D1-D2	16 bits	01111110

The presence of a "1" in any of the bit positions of this data indicates that the device represented by that bit is not functioning properly.

D1 Character

Bit Position	Device Tested
0	Spare
1	Spare
2	Spare
3	Spare
4	Spare
5	Spare
6	Spare
7	DRU

D2 Character

Bit Position	Device Tested
0	Spare
1	VMS
2	VMS Drive
3	Spare
4	Spare
5	Spare
6	Spare
7	Spare

Note. All spares shall be set to zero.

30.4.8 Message: TRAVEL LOCK DATA

From: DRU To: Prime System

Number of Data Characters: 12

Data Format: Binary 2's Complement

MESSAGE STRUCTURE

FLAG(F)	ECHO SEQ#(N)	IDENTIFIER(I)	STATUS S1,S2	DATA(D)	ERROR DET. CODE (E)	FLAG(F)
01111110	XXX	00011	16 Bits	D1-D12	16 bits	01111110

The pointing device geodetic azimuth or grid azimuth and pointing device pitch angles representing the travel lock position are stored in memory. If the pointing device is moved from travel lock the reference data is used for returning to the travel lock position.

D1, D2 Characters (16 bits) — Pointing Device Geodetic Azimuth or Grid Azimuth
Range: 6399.9 mils
Resolution: 0.1 mil

D3, D4 Characters (15 bits) — Pointing Device Pitch
Range: -1600 mils to +1600 mils
Resolution: 0.1 mil

D5, D6 Characters (16 bits) — Travel Lock Geodetic or Grid Azimuth Reference
Range: 0 to 6,399.9 mils
Resolution: 0.1 mil

D7, D8 Characters (15 bits) — Travel Lock Pitch Reference
Range: -600 to +600 mils
Resolution: 0.1 mil

D9, D10 Characters (16 bits) — Pointing Device Azimuth Rate
Range: -360 to +360 mils/second
Resolution: 0.18 mil/second

D11, D12 Characters (16 bits) — Pointing Device Pitch Rate
Range: -180 to +180 mils/second
Resolution: 0.18 mil/second

30.4.9 Message: POSITION DATA

From: DRU To: Prime System

Number of Data Characters: 10

Data Format: Binary 2's Complement

MESSAGE STRUCTURE

FLAG(F)	ECHO SEQ#(N)	IDENTIFIER(I)	STATUS S1,S2	DATA(D)	ERROR DET. CODE (E)	FLAG(F)
01111110	XXX	01000	16 Bits	D1-D10	16 bits	01111110

These ten characters of data represent the spheroid, hemisphere, zone, coordinates and altitude.

D1 Character (4 bits) — Spheroid
Range: 1 to 15 (Integer)

D2 Character (7 bits) — Hemisphere and Zone
Range: -60 to +60, (Integer)
+ indicates northern hemisphere;
- indicates southern

D3, D4, D5 Characters (20 bits) — Easting
Range: 0 to 10^6 meters
Resolution: 1 meter

D6, D7, D8 Characters (24 bits) — Northing
Range: 0 to 10^7 meters
Resolution: 1 meter

D9, D10 Characters (15 bits) — Altitude
Range: -9,999 to +9,999 meters
Resolution: 1 meter

30.4.10 Message: DRU ORIENTATION AND POINTING DEVICE DATA

From: DRU To: Prime System

Number of Data Characters: 12

Data Format: Binary 2's Complement

MESSAGE STRUCTURE

FLAG(F)	ECHO SEQ#(N)	IDENTIFIER(I)	STATUS S1,S2	DATA(D)	ERROR DET. CODE (E)	FLAG(F)
01111110	XXX	01010	16 Bits	D1-D12	16 bits	01111110

These twelve data characters represent the DRU Attitudes and Pointing Device Altitudes.

D1, D2 Characters (16 bits) — DRU Geodetic Azimuth or Grid Azimuth
Range: 0-6399.9 mils
Resolution: 0.1 mil

D3, D4 Characters (16 bits) — DRU Pitch
Range: -1600.0 to +1600.0 mils
Resolution: 0.1 mil

D5, D6 Characters (16 bits) — DRU Roll
Range: -3199.9 to +3200.0 mils
Resolution: 0.1 mil

D7, D8 Characters (16 bits) — Pointing Device Geodetic Azimuth or Grid Azimuth
Range: 0 - 6399.9 mils
Resolution: 0.1 mil

D9, D10 Characters (16 bits) — Pointing Device Pitch
Range: -1600.0 to +1600.0 mils
Resolution: 0.1 mil

D11, D12 Characters (16 bits) — Pointing Device Cant
Range: -3199.9 to +3200.0 mils
Resolution: 0.1 mil

30.4.11 Message: STATUS DATA

From: DRU To: Prime System

Number of Data Characters: 0

Data Format: Binary

MESSAGE STRUCTURE

FLAG(F)	ECHO SEQ#(N)	IDENTIFIER(I)	STATUS S1,S2	DATA(D)	ERROR DET. CODE (E)	FLAG(F)
01111110	XXX	00000	16 Bits	None	16 bits	01111110

30.4.12 Message: BORESIGHT ANGLES

From: Prime System To: DRU

Number of Data Characters: 6

Data Format: Binary 2's complement

MESSAGE STRUCTURE

FLAG(F)	ECHO SEQ#(N)	IDENTIFIER(I)	STATUS S1,S2	DATA(D)	ERROR DET. CODE (E)	FLAG(F)
01111110	XXX	10100	16 Bits	D1-D6	16 bits	01111110

This message contains the values of the boresight angles stored in the DRU.

D1, D2 Characters (16 bits) A
Range: 0 to 6399.9 mils
Resolution: 0.1 mils

D3, D4 Characters (16 bits) B
Range: -1600.0 to +1600.0 mils
Resolution: 0.1 mil

D5, D6 Characters (16 bits) Γ
Range: -3199.9 to 3200.0 mils
Resolution: 0.1 mil

30.4.13 Message: EXPANDED STATUS DATA

From: DRU To: Prime System

Number of Data Characters: 2

Data Format: Binary

MESSAGE STRUCTURE

FLAG(F)	ECHO SEQ#(N)	IDENTIFIER(I)	STATUS S1,S2	DATA(D)	ERROR DET. CODE (E)	FLAG(F)
01111110	XXX	11111	16 Bits	D1-D2	16 bits	01111110

The presence of a "1" in any of the bit positions indicates the mode or condition listed below.

D1 Character

BIT POSITION	MODE OR CONDITION
0	DRU operating in extended UTM zone.
1	Altitude is clamped via FIX ALTITUDE command.

Reset all other bits to "0".

30.4.14 Message: SURVEY QUALITY

From: DRU To: Prime System

Number of Data Characters: 6

Data Format: Binary

MESSAGE STRUCTURE

FLAG(F)	ECHO SEQ#(N)	IDENTIFIER(I)	STATUS S1,S2	DATA(D)	ERROR DET. CODE (E)	FLAG(F)
01111110	XXX	10101	16 Bits	D1-D6	16 bits	01111110

D1, D2 Characters (16 bits) — Filter estimate of Azimuth error (1σ)
Range: 0 to 6399.9 mils
Resolution: 0.1 mil

D3, D4 Characters (16 bits) — Filter estimate of Horizontal Position error (1σ)
Range: 0 to 65536 meters
Resolution: 1 meter

D5, D6 Characters (16 bits) — Filter estimate of Altitude error (1σ)
Range: 0 to 65536 meters
Resolution: 1 meter

APPENDIX E

DESCRIPTION OF STATUS CHARACTERS

30.5 STATUS CHARACTERS.

The presence of a "1" in any of the bit positions indicates that the mode or condition listed below exists. The conditions which cause setting or resetting of the bits are described in Table 30.5.

S1 CHARACTER

BIT POSITION	MODE OR CONDITION
0	Auxiliary Bus Control is inhibited.
1	Position update request.
2	Zero-Velocity stop request.
3	DRU is in ZUPT mode.
4	DRU is in survey mode.
5	DRU is in Normal Align, Realign, or Stored Heading Align mode.
6	Vehicle moving.
7	DRU is in startup mode.

S2 CHARACTER

BIT POSITION	MODE OR CONDITION
0	DRU is in first 5 minutes of Normal Align mode.
1	DRU alert. An illegal operation was attempted.
2	DRU is in Stored Heading Align mode.
3	Shot detect.
4	Indicates that the Pointing Device is in travel lock.
5	The DRU, VMS, or VMS Drive has malfunctioned.
6	Position update in progress.
7	Zero-velocity update in progress.

TABLE 30.5. STATUS BIT ACTIVATION CONDITIONS

CHAR/BIT	SET CONDITION	RESET CONDITION
S1/0	Receipt of INHIBIT AUXILIARY BUS CONTROL Command.	Receipt of ENABLE AUXILIARY BUS CONTROL Command or Main Bus inactivity.
1	DRU determines it needs a position update.	Position update initiated
2	DRU determines it needs a zero-velocity stop to control system errors.	Zero-velocity update initiated or zero velocity update not needed at the present time.
3	DRU determines it is operating in a ZUPT mode.	DRU determines it is operating in the odometer aided mode.
4	DRU enters survey mode.	DRU is not in survey mode.
5	DRU enters Normal Align, Realign, or Stored Heading Align mode.	DRU is not in an align mode.
6	DRU determines that the vehicle is moving.	DRU determines that the vehicle is stopped.
7	Turn-on.	DRU operations and thermal control sufficient for proceeding with Normal Align.

CHAR/BIT	SET CONDITION	RESET CONDITION
S2/0	DRU enters Normal Align.	DRU has been in Normal Align mode 5 minutes
1	Setting of an ALERT DATA bit.	Resetting of all ALERT DATA bits.

(Note: STATUS reporting of ALERT DATA may be different on the Main and Auxiliary data buses. Bus related ALERT DATA shall be reported only over the applicable bus.)

2	DRU enters Stored Heading Align mode.	DRU enters survey or Normal Align mode.
3	DRU has detected a gun shot.	Two second time delay after shot detection.
4	Pointing device is in travel lock.	Pointing device is out of travel lock.
5	DRU determines the DRU, VMS, or VMS Drive has failed.	Failure corrected.
6	Initialization of a position update.	Completion of a position update.
7	Zero-velocity update initiation.	Completion or interruption of the zero-velocity update.

APPENDIX F

CONFIGURATION DATA

	CONFIGURATION DISCRETE 1	2	3	4
CONFIGURATION CODE: 0	0	0	0	0

PRIME SYSTEM: HOWITZER IMPROVEMENT PROGRAM (HIP)

DRU COORDINATE FRAME ROTATION MATRIX:

r_{11}	r_{12}	r_{13}	r_{21}	r_{22}	r_{23}	r_{31}	r_{32}	r_{33}
1	0	0	0	1	0	0	0	1

VEHICLE BORESIGHT ANGLES:	α:	0.0	mils
	β:	0.0	mils
	τ:	0.0	mils
POINTING DEVICE BORESIGHT ANGLES:	A:	0.0	mils
	B:	-88.9	mils
	Γ:	0.0	mils
VEHICLE OFFSET DISTANCES:	ΔX:	3.1	meters
	ΔY:	-2.1	meters
	ΔZ:	-2.2	meters
ZUPT INTERVALS:	ZUPT MODE:	4.0	minutes
	ODOMETER MODE:	60.0	minutes
ALIGN TIMES:	NORMAL:	15.0	minutes
	STORED HEADING:	1.5	minutes
	REALIGN:	3.5	minutes
VMS SCALE FACTOR:		1.0	
FUEL CONSUMPTION FACTOR:		0.93×10^{-8}	rad/m

CONFIGURATION DEFINITION FLAGS:

ODOMETER/EXCLUSIVE ZUPT MODE:	1
TRACKED/WHEELED VEHICLE:	1
TRAVEL LOCK DISCRETE:	1
TRAVEL LOCK COMMANDS:	0
SHOT DETECT:	1
POINTING DEVICE BORESIGHT ANGLES:	0
GEODETIC/GRID AZIMUTH:	0
VEHICLE CANT/ROLL:	0

	CONFIGURATION DISCRETE 1	2	3	4
CONFIGURATION CODE: 1	0	0	0	1

PRIME SYSTEM: M110 SELF-PROPELLED HOWITZER

DRU COORDINATE FRAME ROTATION MATRIX:

r_{11} r_{12} r_{13} r_{21} r_{22} r_{23} r_{31} r_{32} r_{33}

VEHICLE BORESIGHT ANGLES:	α:		mils
	β:		mils
	τ:		mils
POINTING DEVICE BORESIGHT ANGLES:	A:		mils
	B:		mils
	Γ:		mils
VEHICLE OFFSET DISTANCES:	X:		meters
	Y:		meters
	Z:		meters
ZUPT INTERVALS:	ZUPT MODE:	4.0	minutes
	ODOMETER MODE:	60.0	minutes
ALIGN TIMES:	NORMAL:	15.0	minutes
	STORED HEADING:	1.5	minutes
	REALIGN:	3.5	minutes
VMS SCALE FACTOR:		1.0	
FUEL CONSUMPTION FACTOR:		0.0	rad/m

CONFIGURATION DEFINITION FLAGS:

ODOMETER/EXCLUSIVE ZUPT MODE:	1
TRACKED/WHEELED VEHICLE:	1
TRAVEL LOCK DISCRETE:	1
TRAVEL LOCK COMMANDS:	0
SHOT DETECT:	1
POINTING DEVICE BORESIGHT ANGLES:	0
GEODETIC/GRID AZIMUTH:	0
VEHICLE CANT/ROLL:	0

CONFIGURATION DISCRETE

1	2	3	4
1	1	1	0

CONFIGURATION CODE: 14

PRIME SYSTEM: WARRIOR

DRU COORDINATE FRAME ROTATION MATRIX:

r_{11} r_{12} r_{13} r_{21} r_{22} r_{23} r_{31} r_{32} r_{33}

VEHICLE BORESIGHT ANGLES:
α: mils.
β: mils
τ: mils

POINTING DEVICE BORESIGHT ANGLES:
A: mils
B: mils
Γ: mils

VEHICLE OFFSET DISTANCES:
X: meters
Y: meters
Z: meters

ZUPT INTERVALS:
ZUPT MODE: minutes
ODOMETER MODE: minutes

ALIGN TIMES:
NORMAL: minutes
STORED HEADING: minutes
REALIGN: minutes

VMS SCALE FACTOR:

FUEL CONSUMPTION FACTOR: rad/m

CONFIGURATION DEFINITION FLAGS:

ODOMETER/EXCLUSIVE ZUPT MODE:
TRACKED/WHEELED VEHICLE:
TRAVEL LOCK DISCRETE:
TRAVEL LOCK COMMANDS:
SHOT DETECT:
POINTING DEVICE BORESIGHT ANGLES:
GEODETIC/GRID AZIMUTH:
VEHICLE CANT/ROLL:

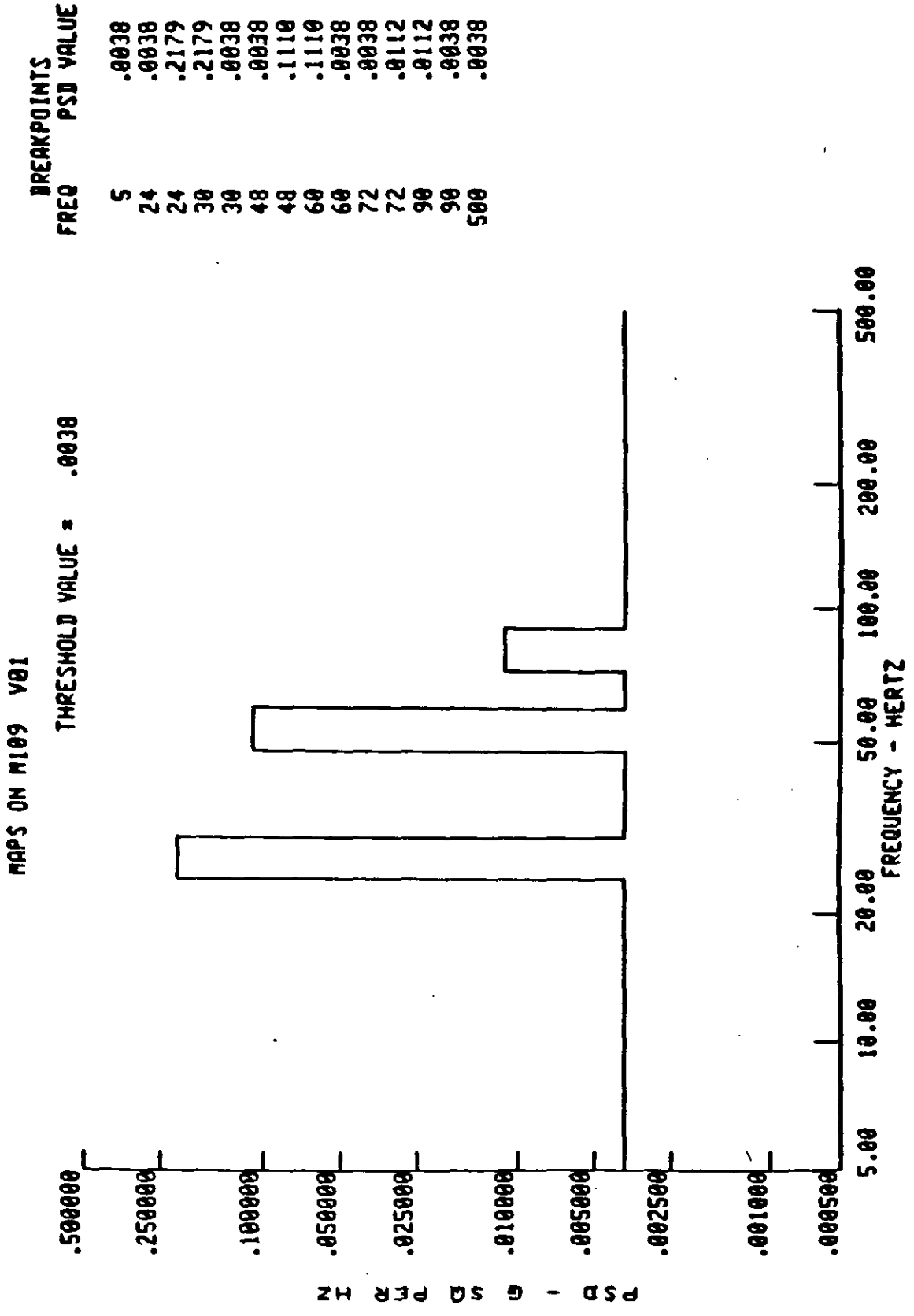
CONFIGURATION DISCRETE			
1	2	3	4
1	1	1	1

CONFIGURATION CODE: 15

DESIGNATES CONFIGURATION DATA TO BE SUPPLIED USING AN ACCEPT CONFIGURATION DATA COMMAND.

APPENDIX G

VIBRATION TEST SCHEDULES



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 V01

TEST TIME, MINUTES: 54.0 DELTA F, HZ: 1.0 OVERALL RMS, G: 1.80

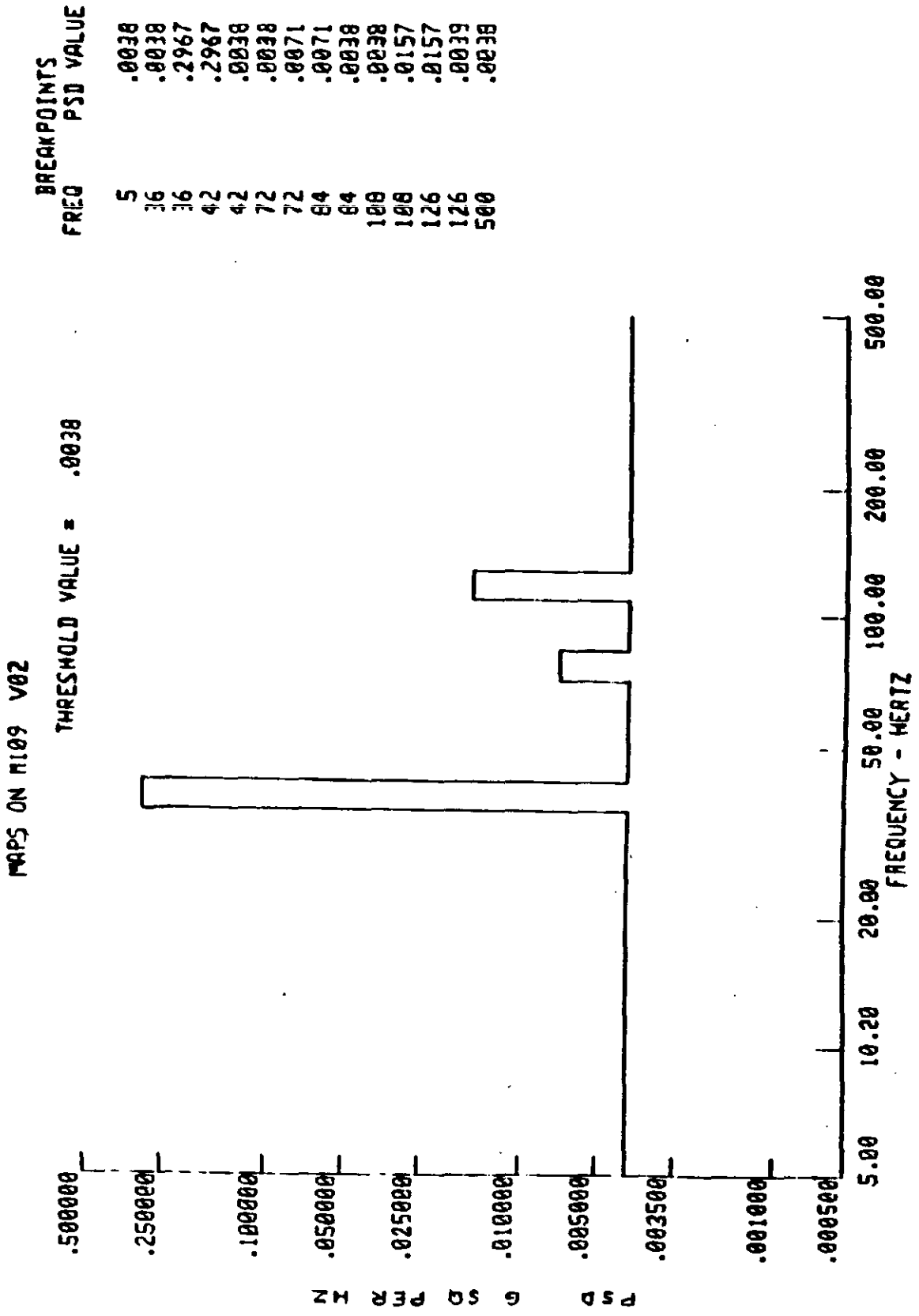
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
24.0	30.0	3.0	.21790	17.6
48.0	60.0	6.0	.11100	14.7
72.0	90.0	9.0	.01120	4.7
		FLOOR VALUES		
5.0	500.0	495.0	.00380	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
10	9
9	11
8	12
7	15
6	18
5	20
4	20
3	20
2	20
1	20

*** USE 9 SWEEPS AND 11 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 20 DB ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 V02

TEST TIME, MINUTES: 54.0 DELTA F, HZ: 1.0 OVERALL RMS, G: 1.70

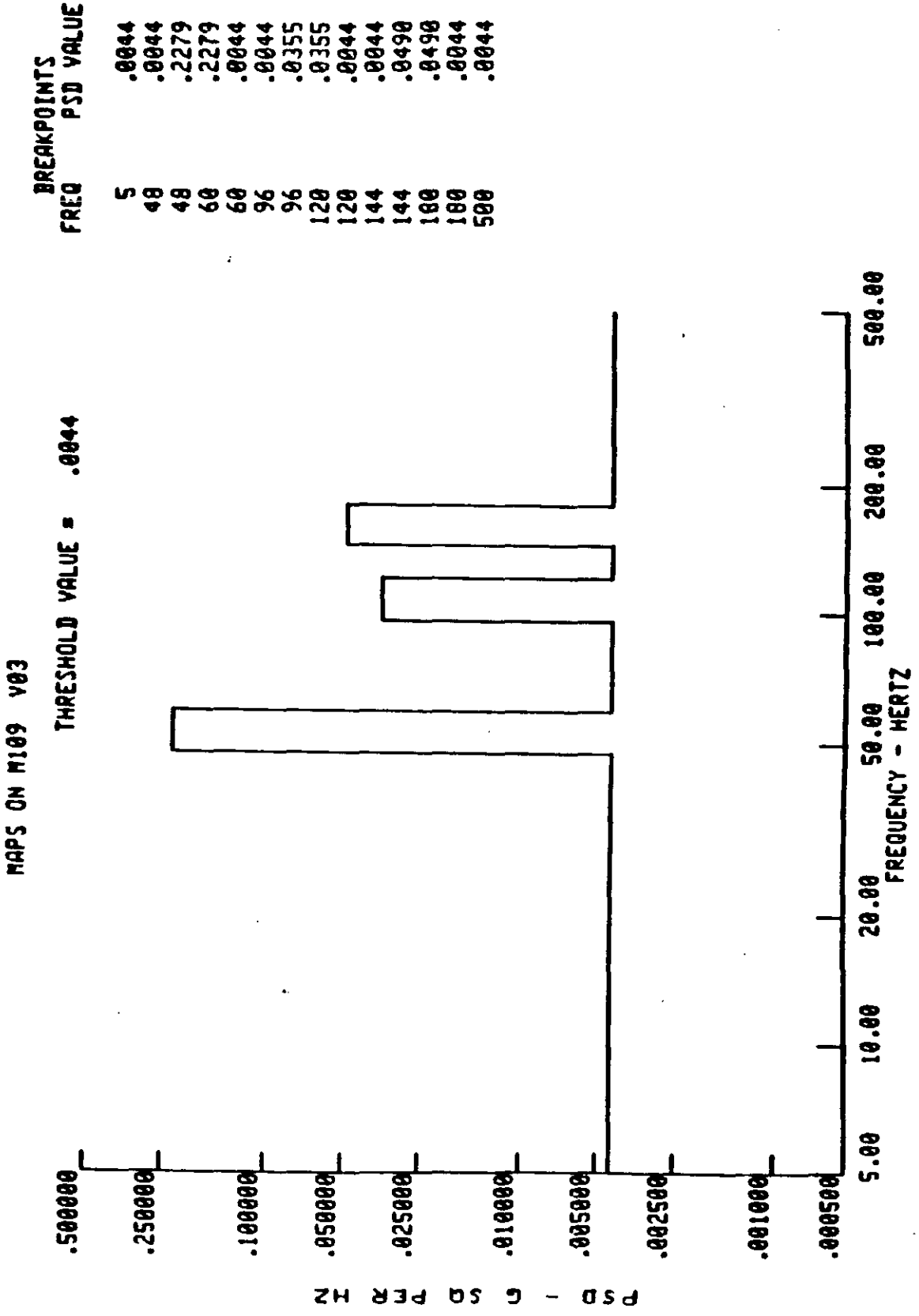
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
36.0	42.0	3.0	.29670	18.9
72.0	84.0	6.0	.00710	2.7
108.0	126.0	9.0	.01570	6.2
		FLOOR VALUES		
5.0	500.0	495.0	.00380	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
10	9
9	11
8	12
7	15
6	18
5	20
4	20
3	20
2	20
1	20

*** USE 9 SWEEPS AND 11 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 25 DB ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 V03

TEST TIME, MINUTES: 54.0 DELTA F, HZ: 1.0 OVERALL RMS, G: 2.17

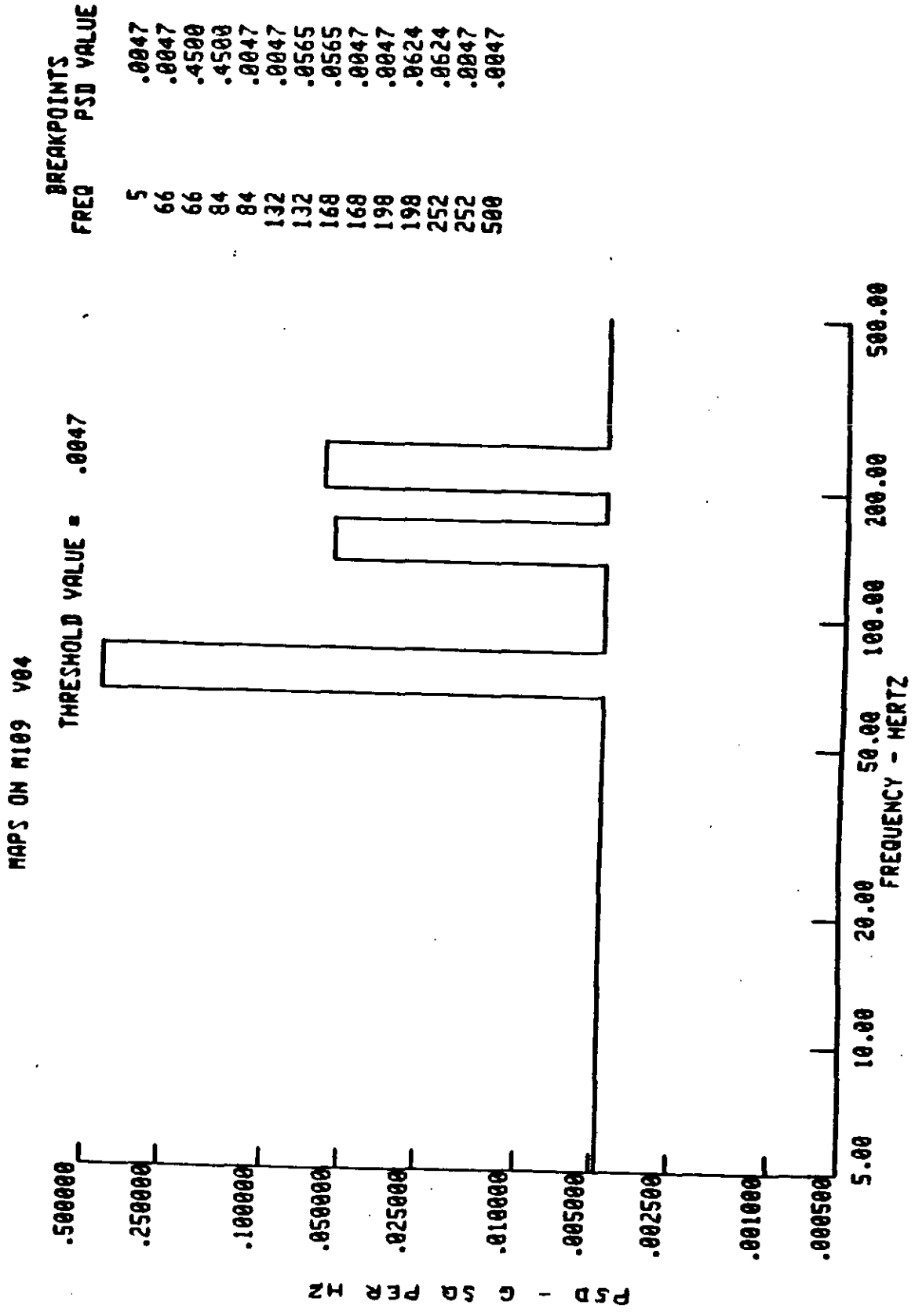
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
48.0	60.0	6.0	.22790	17.1
96.0	120.0	12.0	.03550	9.1
144.0	180.0	18.0	.04900	10.5
		FLOOR VALUES		
5.0	500.0	495.0	.00440	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
10	2
9	3
8	4
7	5
6	7
5	9
4	12
3	18
2	20
1	20

*** USE 4 SWEEPS AND 12 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 20 DB ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 V04

TEST TIME, MINUTES: 54.0 DELTA F, HZ: 1.0 OVERALL RMS, G: 2.97

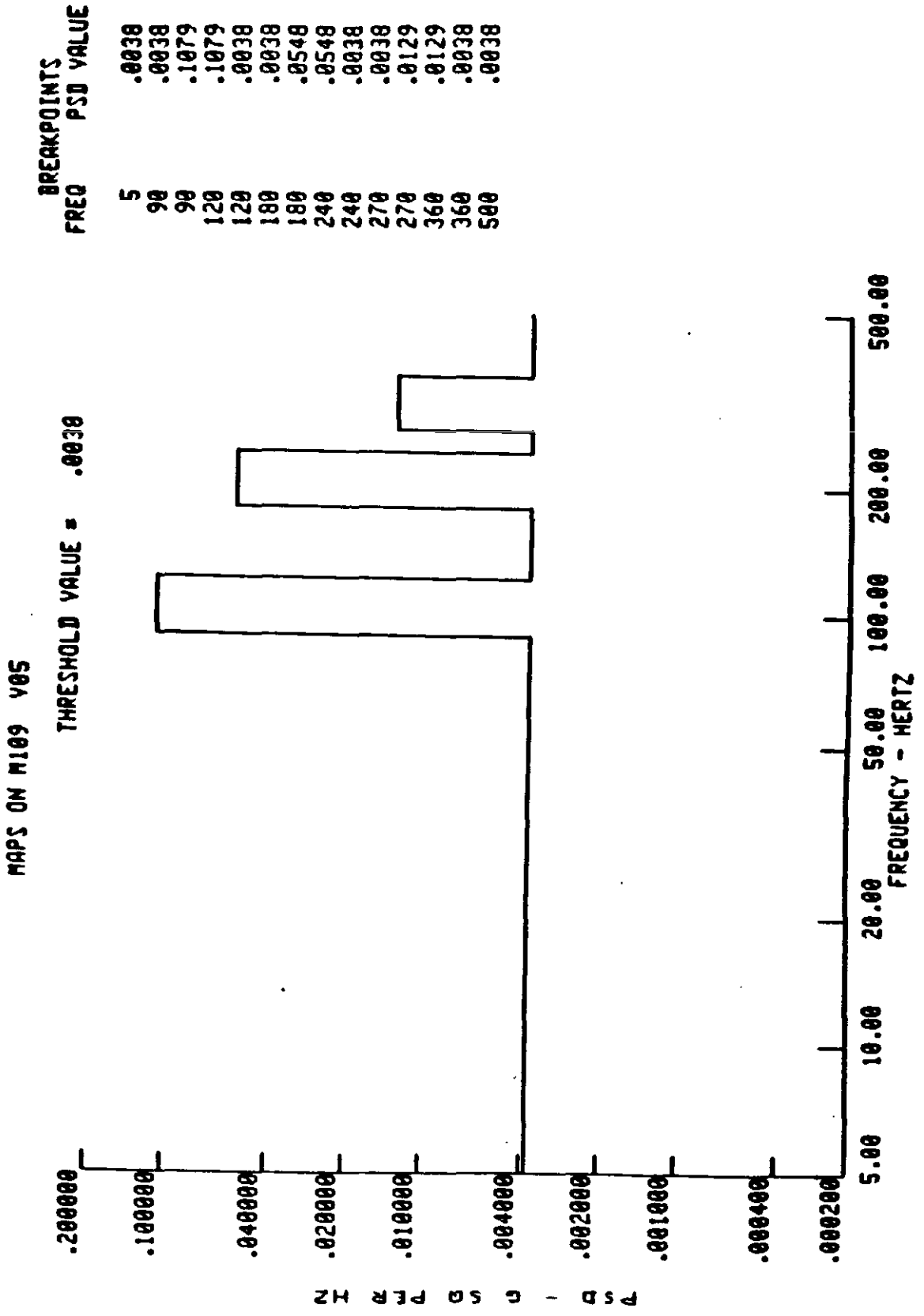
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
66.0	84.0	9.0	.45000	19.8
132.0	168.0	18.0	.05650	10.8
198.0	252.0	27.0	.06240	11.2
		FLOOR VALUES		
5.0	500.0	495.0	.00470	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
8	1
7	2
6	3
5	4
4	7
3	11
2	18
1	20

*** USE 3 SWEEPS AND 11 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 25 DB ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 V05

TEST TIME, MINUTES: 54.0 DELTA F, HZ: 1.0 OVERALL RMS, G: 2.32

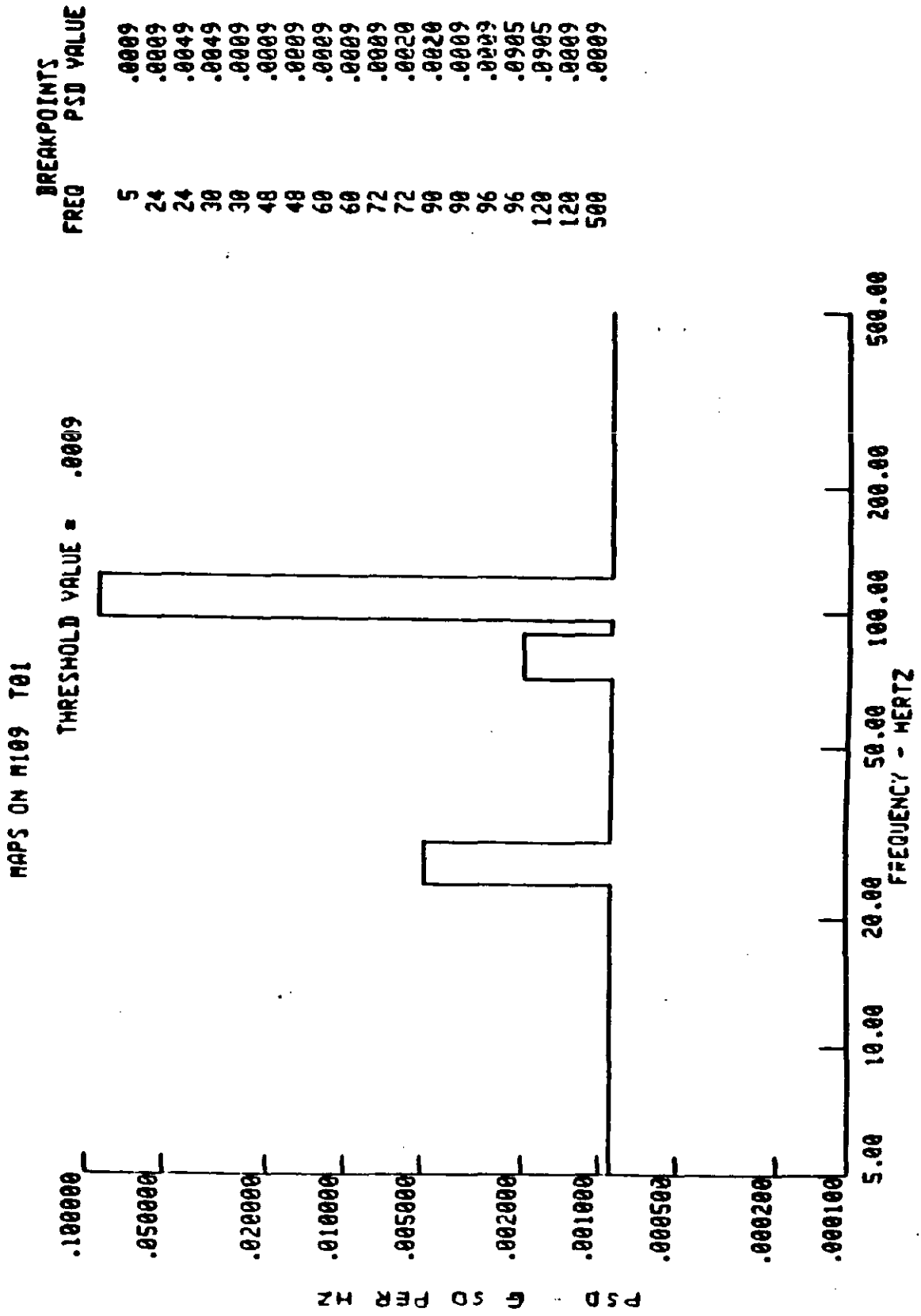
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
90.0	120.0	15.0	.10790	14.5
180.0	240.0	30.0	.05480	11.6
270.0	360.0	45.0	.01290	5.3
		FLOOR VALUES		
5.0	500.0	495.0	.00380	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
4	2
3	4
2	9
1	20

*** USE 2 SWEEPS AND 9 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 20 DB ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 T01

TEST TIME, MINUTES: 54.0 DELTA F, HZ: 1.0 OVERALL RMS, G: 1.24

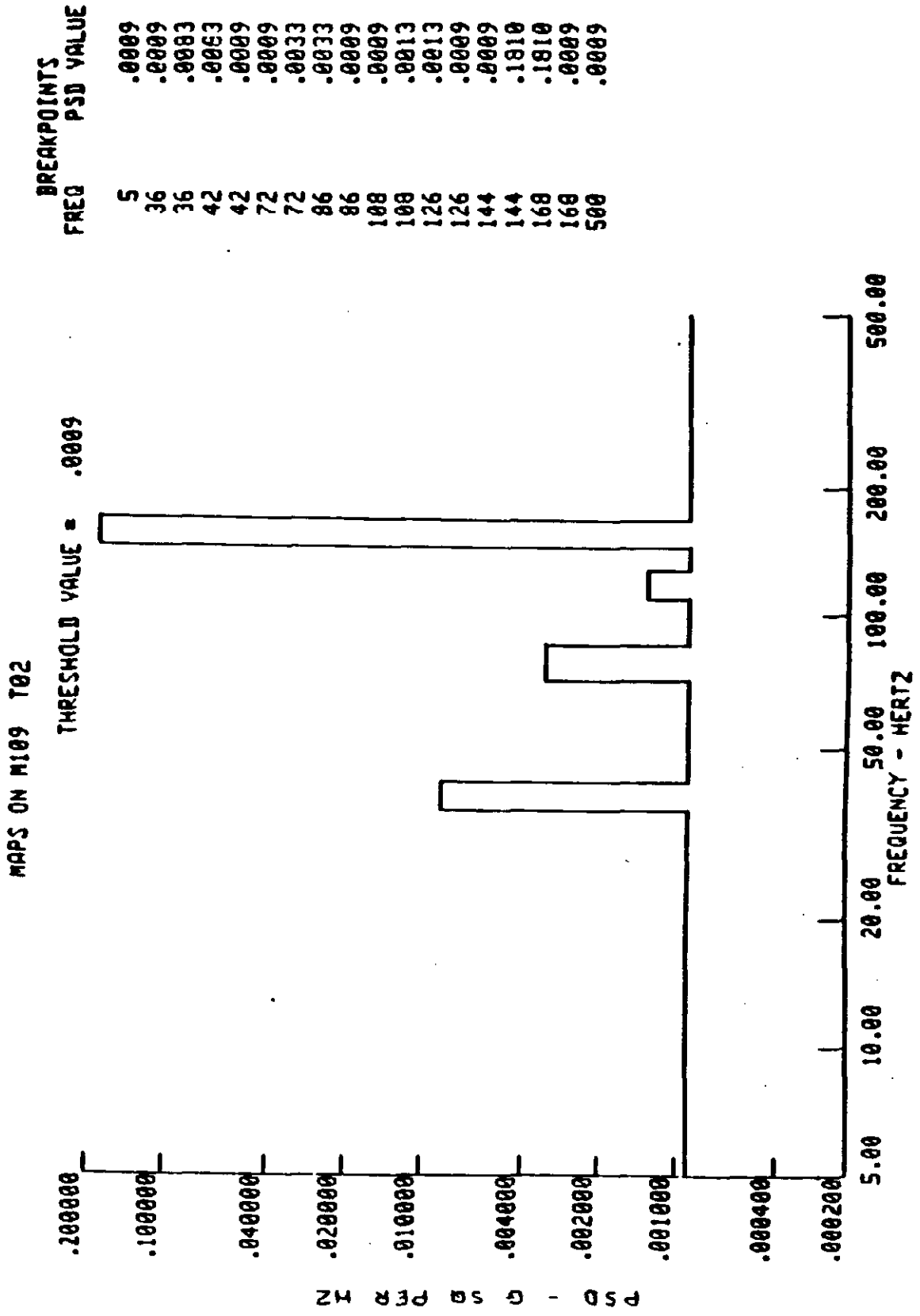
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
24.0	30.0	3.0	.00490	7.4
48.0	60.0	6.0	.00091	.0
72.0	90.0	9.0	.00200	3.5
96.0	120.0	12.0	.09050	20.0
		FLOOR VALUES		
5.0	500.0	495.0	.00090	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
10	5
9	7
8	8
7	10
6	12
5	16
4	20
3	20
2	20
1	20

*** USE 7 SWEEPS AND 10 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 25 DB ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 T02

TEST TIME, MINUTES: 54.0 DELTA F, HZ: 1.0 OVERALL RMS, G: 1.63

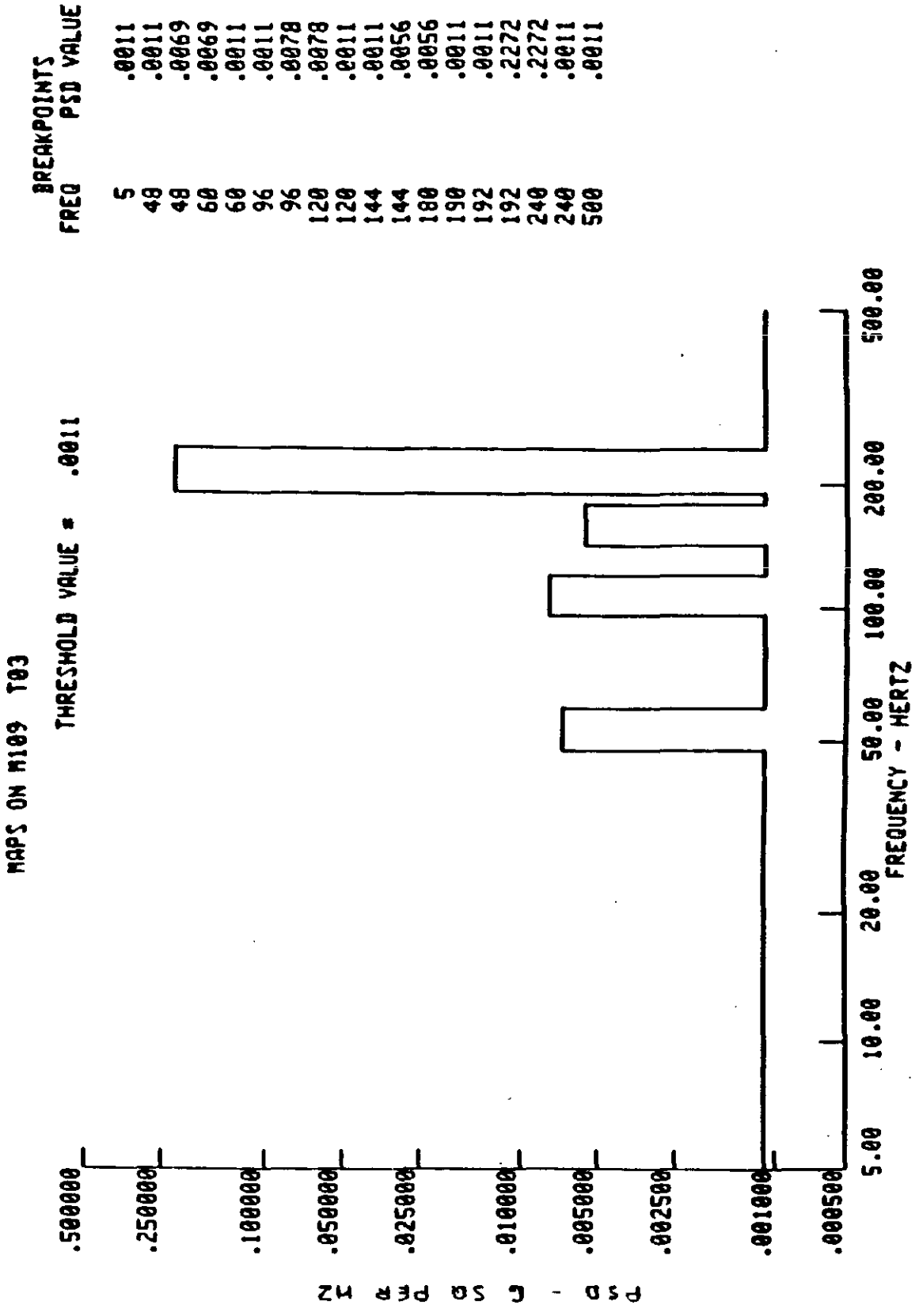
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
36.0	42.0	3.0	.00830	9.6
72.0	84.0	6.0	.00330	5.6
108.0	126.0	9.0	.00130	1.6
144.0	168.0	12.0	.18100	23.0
		FLOOR VALUES		
5.0	500.0	495.0	.00090	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
10	5
9	7
8	8
7	10
6	12
5	16
4	20
3	20
2	20
1	20

*** USE 7 SWEEPS AND 10 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 25 DB ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 T03

TEST TIME, MINUTES: 54.0 DELTA F, HZ: 1.0 OVERALL RMS, G: 2.48

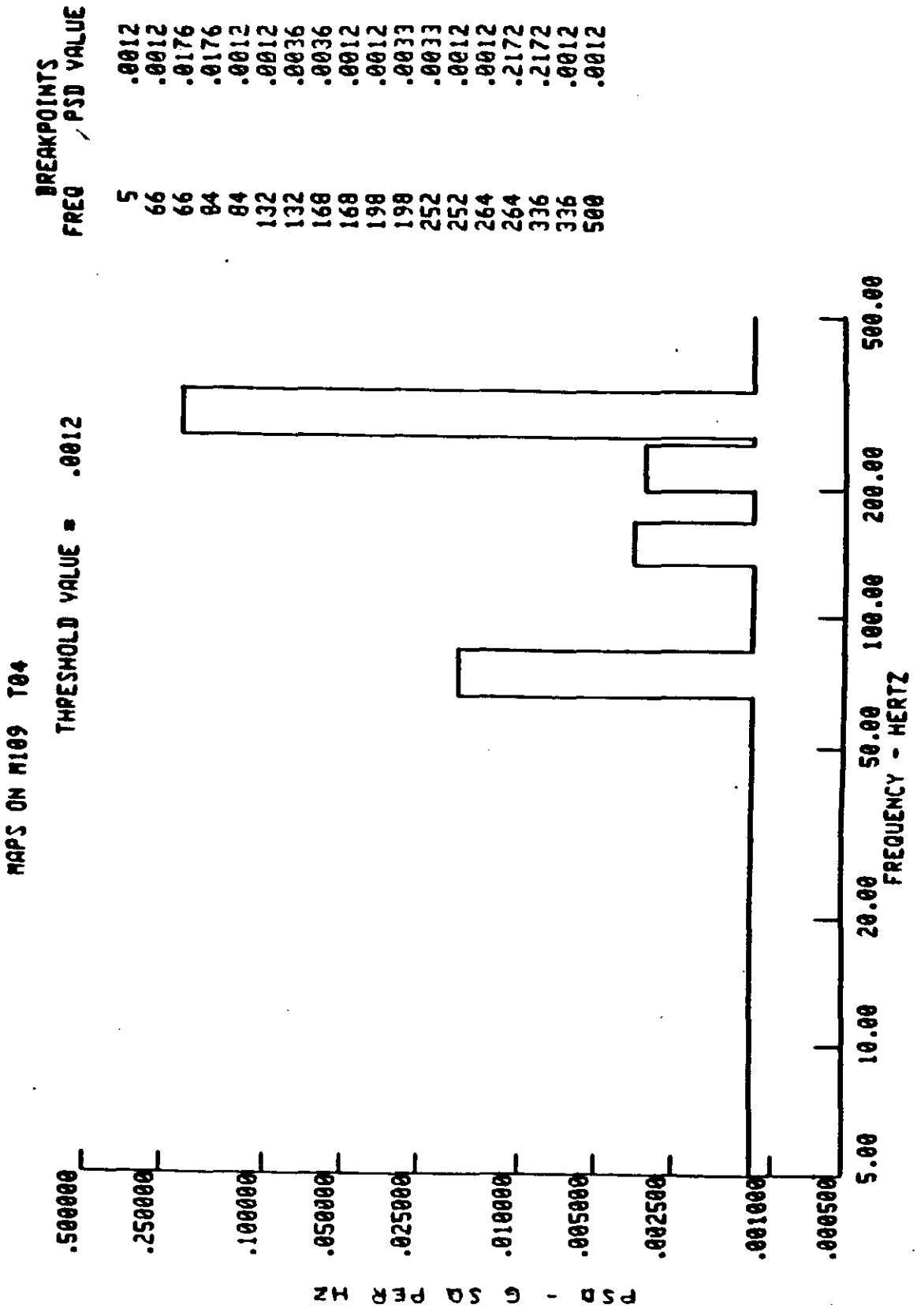
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
48.0	60.0	6.0	.00690	8.0
96.0	120.0	12.0	.00780	8.5
144.0	180.0	18.0	.00560	7.1
192.0	240.0	24.0	.22720	23.2
		FLOOR VALUES		
5.0	500.0	495.0	.00110	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
9	1
8	1
7	2
6	4
5	5
4	8
3	12
2	20
1	20

*** USE 3 SWEEPS AND 12 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 25 DB ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 T04

TEST TIME, MINUTES: 54.0 DELTA F, HZ: 1.0 OVERALL RMS, G: 2.94

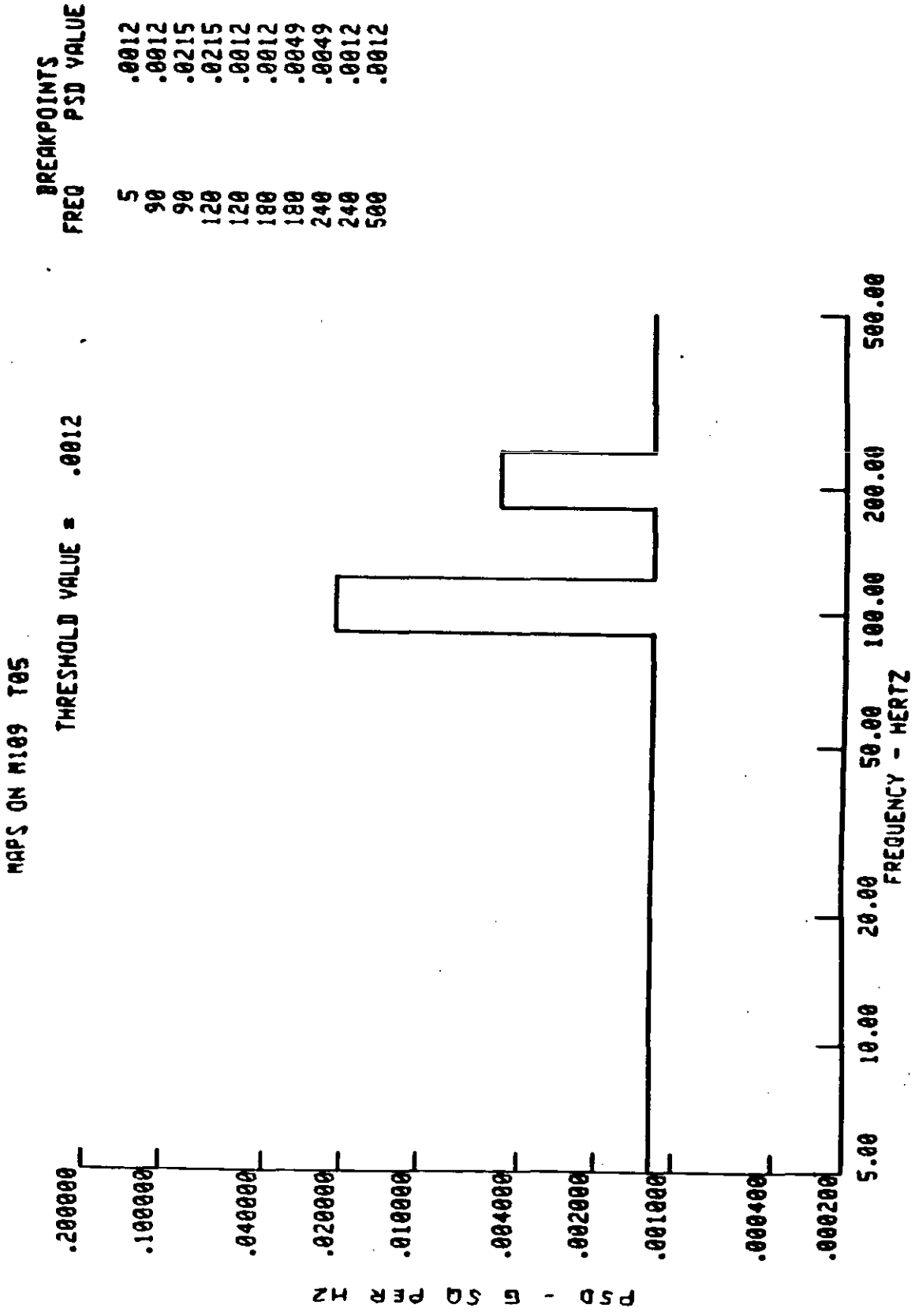
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
66.0	84.0	9.0	.01760	11.7
132.0	168.0	18.0	.00360	4.8
198.0	252.0	27.0	.00330	4.4
264.0	336.0	36.0	.21720	22.6
		FLOOR VALUES		
5.0	500.0	495.0	.00120	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
6	1
5	2
4	4
3	7
2	12
1	20

*** USE 2 SWEEPS AND 12 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 25 DB ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 T05

TEST TIME, MINUTES: 54.0 DELTA F, HZ: 1.0 OVERALL RMS, G: 1.00

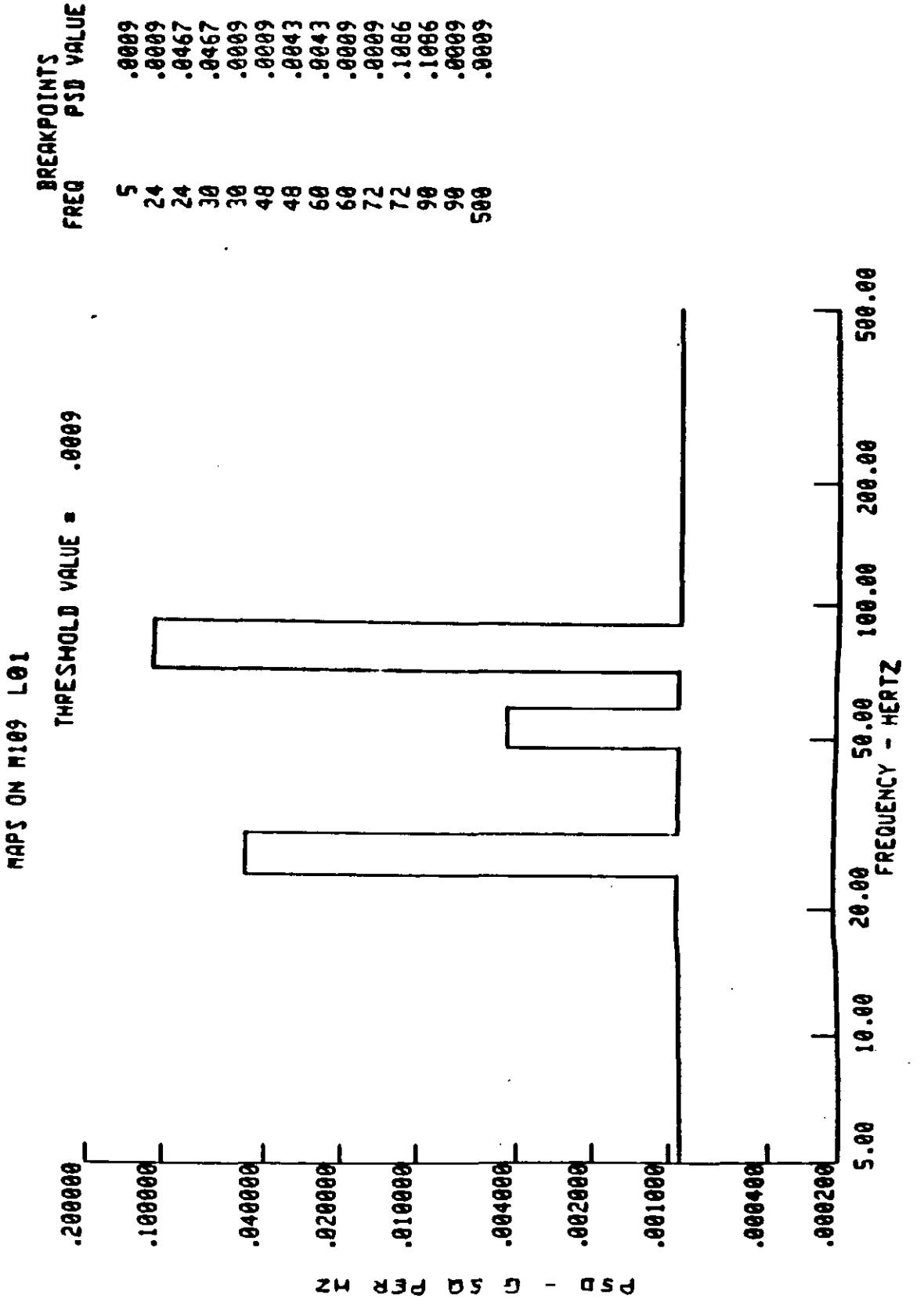
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
90.0	120.0	15.0	.02150	12.5
180.0	240.0	30.0	.00490	6.1
		FLOOR VALUES		
5.0	500.0	495.0	.00120	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
7	1
6	2
5	3
4	5
3	9
2	16
1	20

*** USE 2 SWEEPS AND 16 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 20 DB ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 L01

TEST TIME, MINUTES: 54.0 DELTA F, HZ: 1.0 OVERALL RMS, G: 1.25

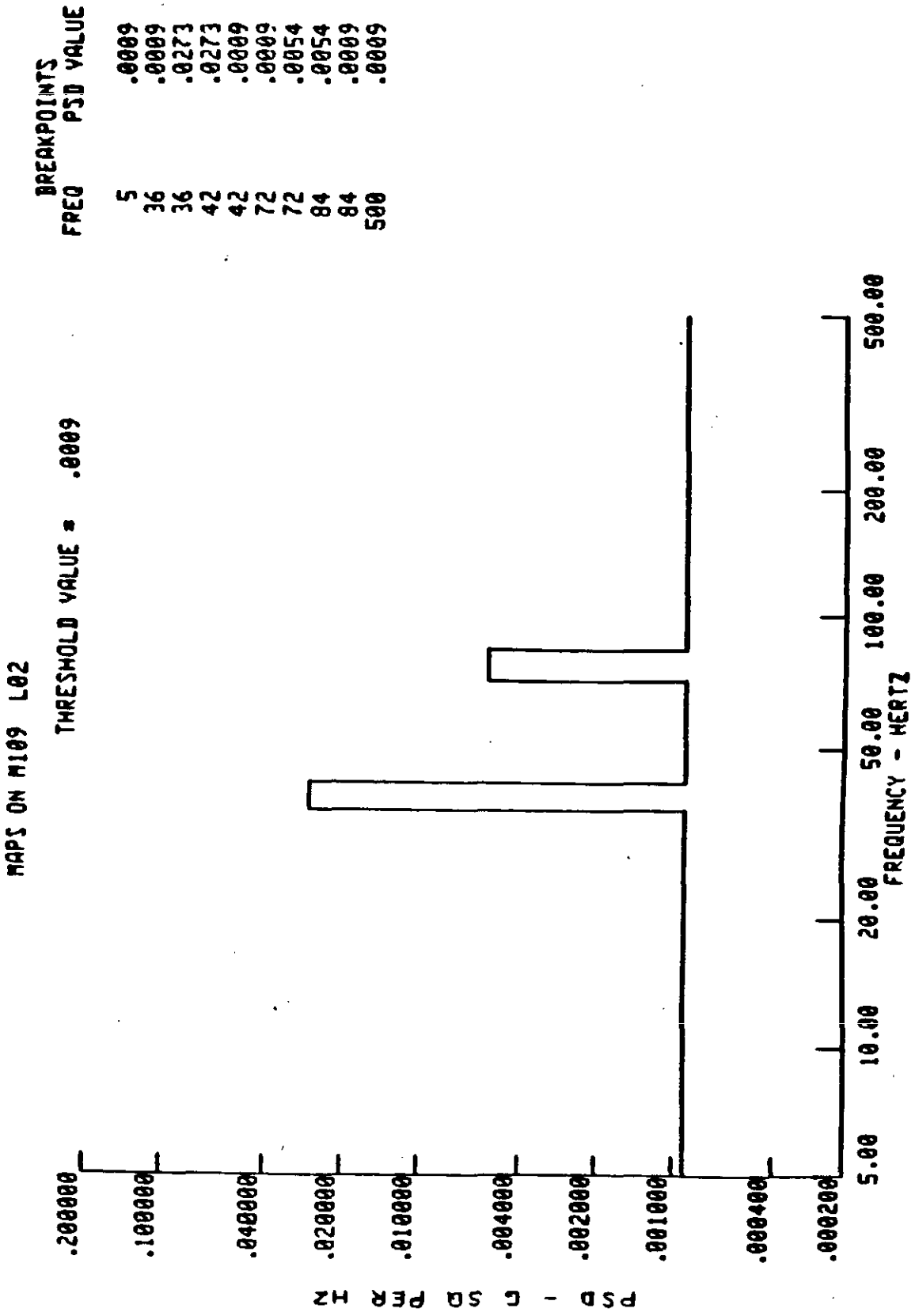
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
24.0	30.0	3.0	.04670	17.2
48.0	60.0	6.0	.00430	6.8
72.0	90.0	9.0	.10860	20.8
		FLOOR VALUES		
5.0	500.0	495.0	.00090	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
10	9
9	11
8	12
7	15
6	18
5	20
4	20
3	20
2	20
1	20

*** USE 9 SWEEPS AND 11 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 25 DB ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 L02

TEST TIME, MINUTES: 54.0 DELTA F, HZ: 1.0 OVERALL RMS, G: .74

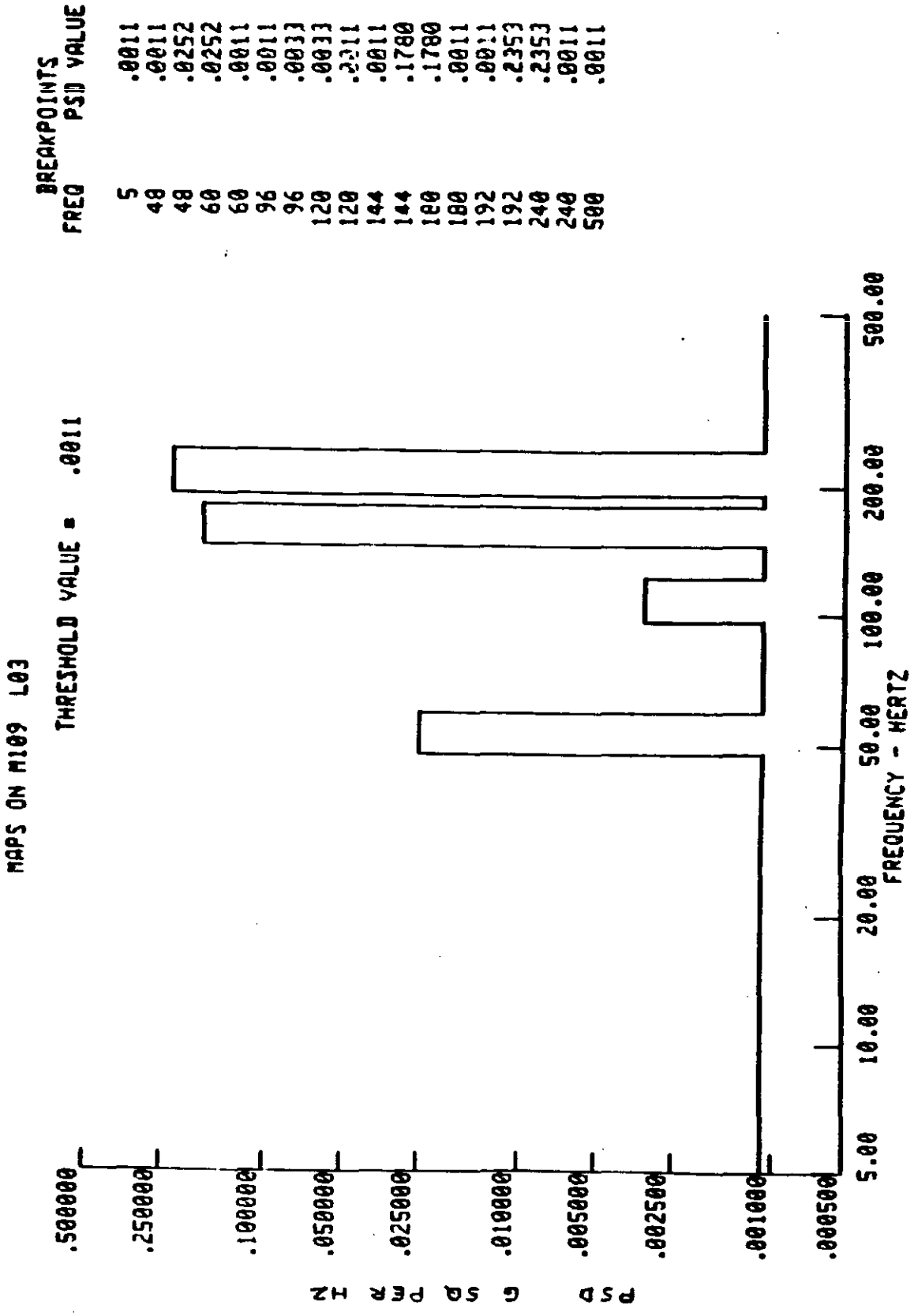
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
36.0	42.0	3.0	.02730	14.8
72.0	84.0	6.0	.00540	7.8
		FLOOR VALUES		
5.0	500.0	495.0	.00090	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
10	16
9	18
8	20
7	20
6	20
5	20
4	20
3	20
2	20
1	20

*** USE 10 SWEEPS AND 16 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 20 DB ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 L03

TEST TIME, MINUTES: 54.0 DELTA F, HZ: 1.0 OVERALL RMS, G: 3.09

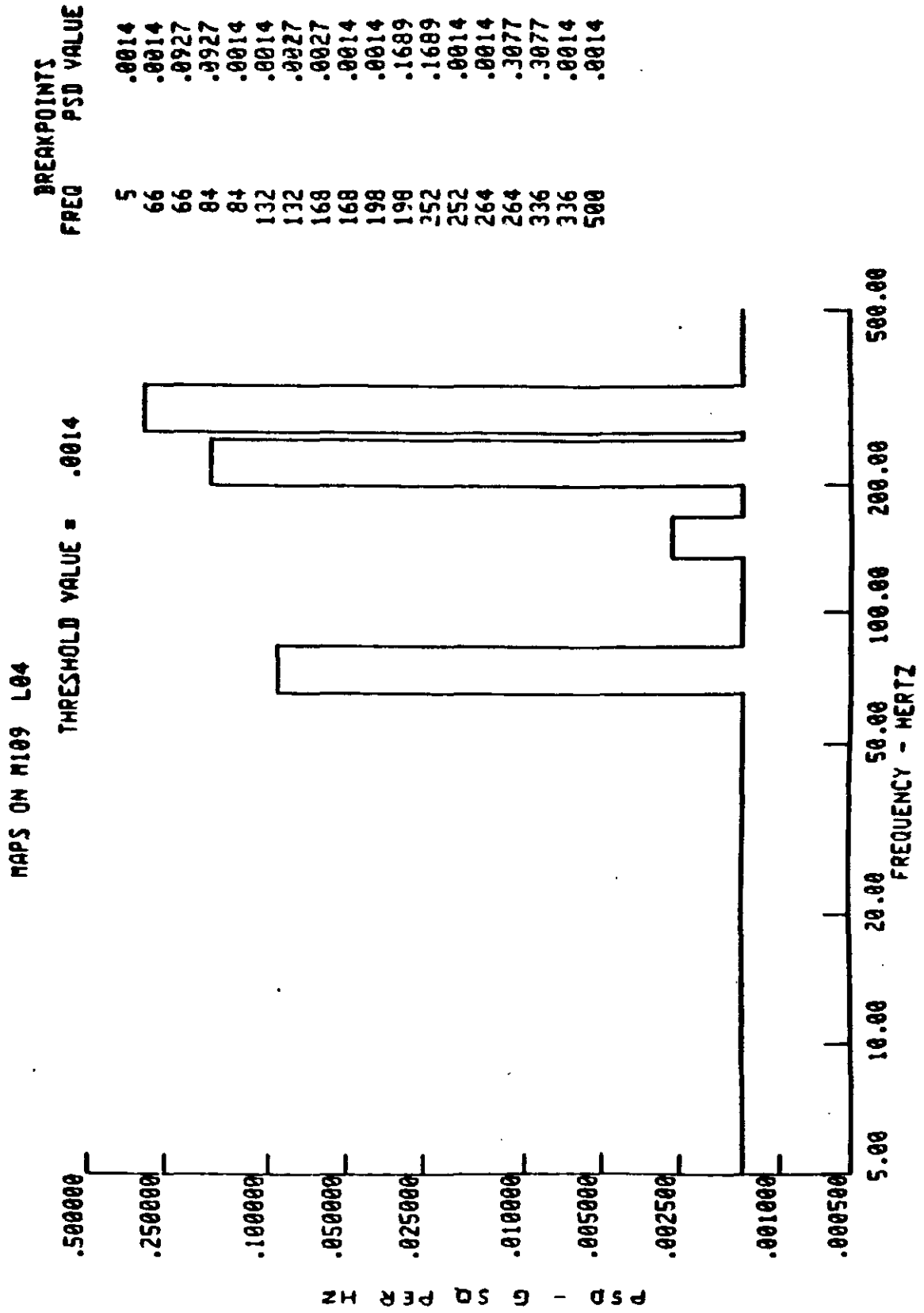
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
48.0	60.0	6.0	.02520	13.6
96.0	120.0	12.0	.00330	4.8
144.0	180.0	18.0	.17800	22.1
192.0	240.0	24.0	.23530	23.3
		FLOOR VALUES		
5.0	500.0	495.0	.00110	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
9	1
8	1
7	2
6	4
5	5
4	8
3	12
2	20
1	20

*** USE 3 SWEEPS AND 12 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 25 DB ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 L04

TEST TIME, MINUTES: 54.0 DELTA F, HZ: 1.0 OVERALL RMS, G: 4.13

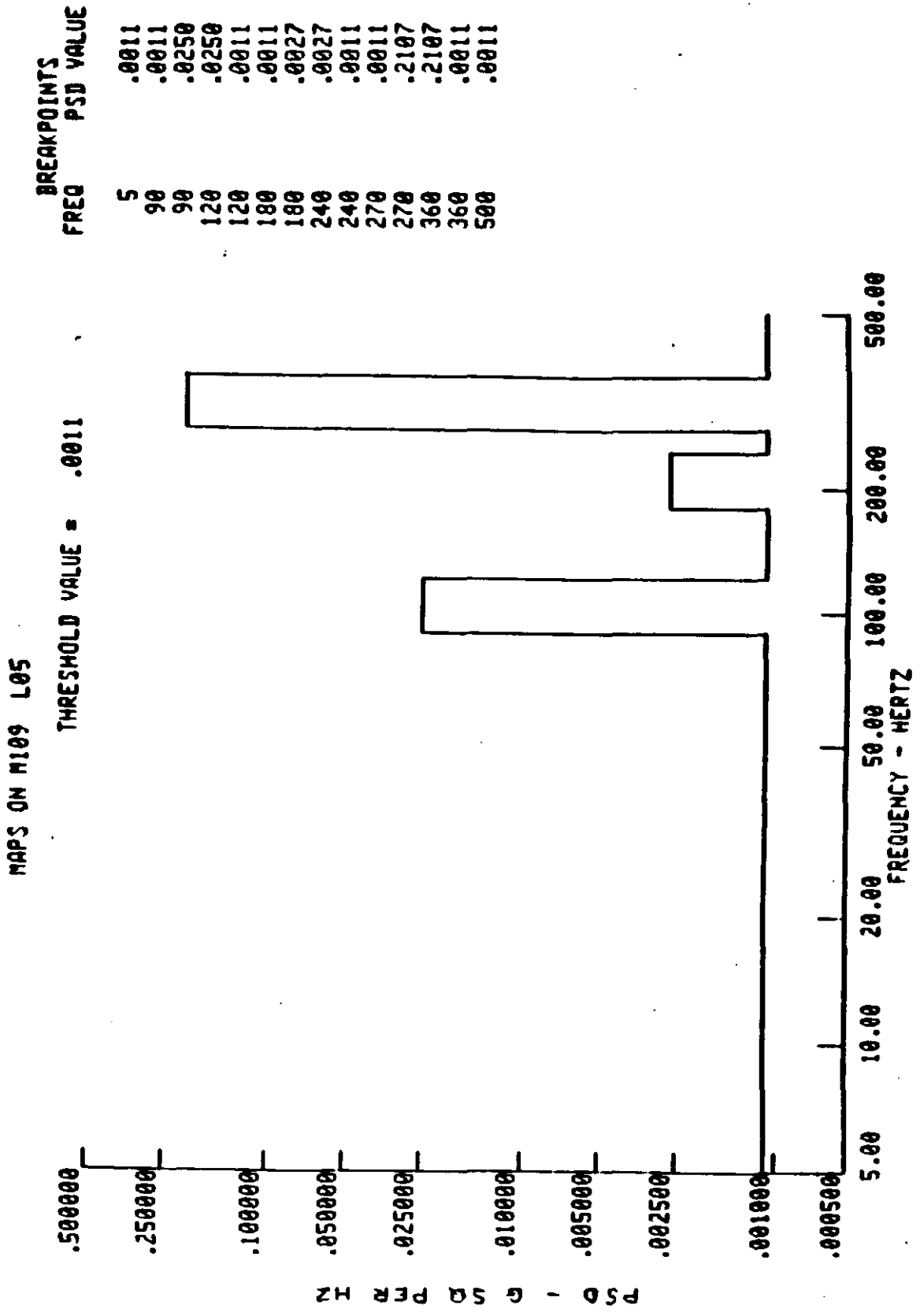
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
66.0	84.0	9.0	.09270	18.2
132.0	168.0	18.0	.00270	2.9
198.0	252.0	27.0	.16890	20.8
264.0	336.0	36.0	.30770	23.4
		FLOOR VALUES		
5.0	500.0	495.0	.00140	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
6	1
5	2
4	4
3	7
2	12
1	20

*** USE 2 SWEEPS AND 12 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 25 DB ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 L05

TEST TIME, MINUTES: 54.0 DELTA F, HZ: 1.0 OVERALL RMS, G: 3.22

START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
90.0	120.0	15.0	.02500	13.6
180.0	240.0	30.0	.00270	3.9
270.0	360.0	45.0	.21070	22.8
		FLOOR VALUES		
5.0	500.0	495.0	.00110	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
4	2
3	4
2	9
1	20

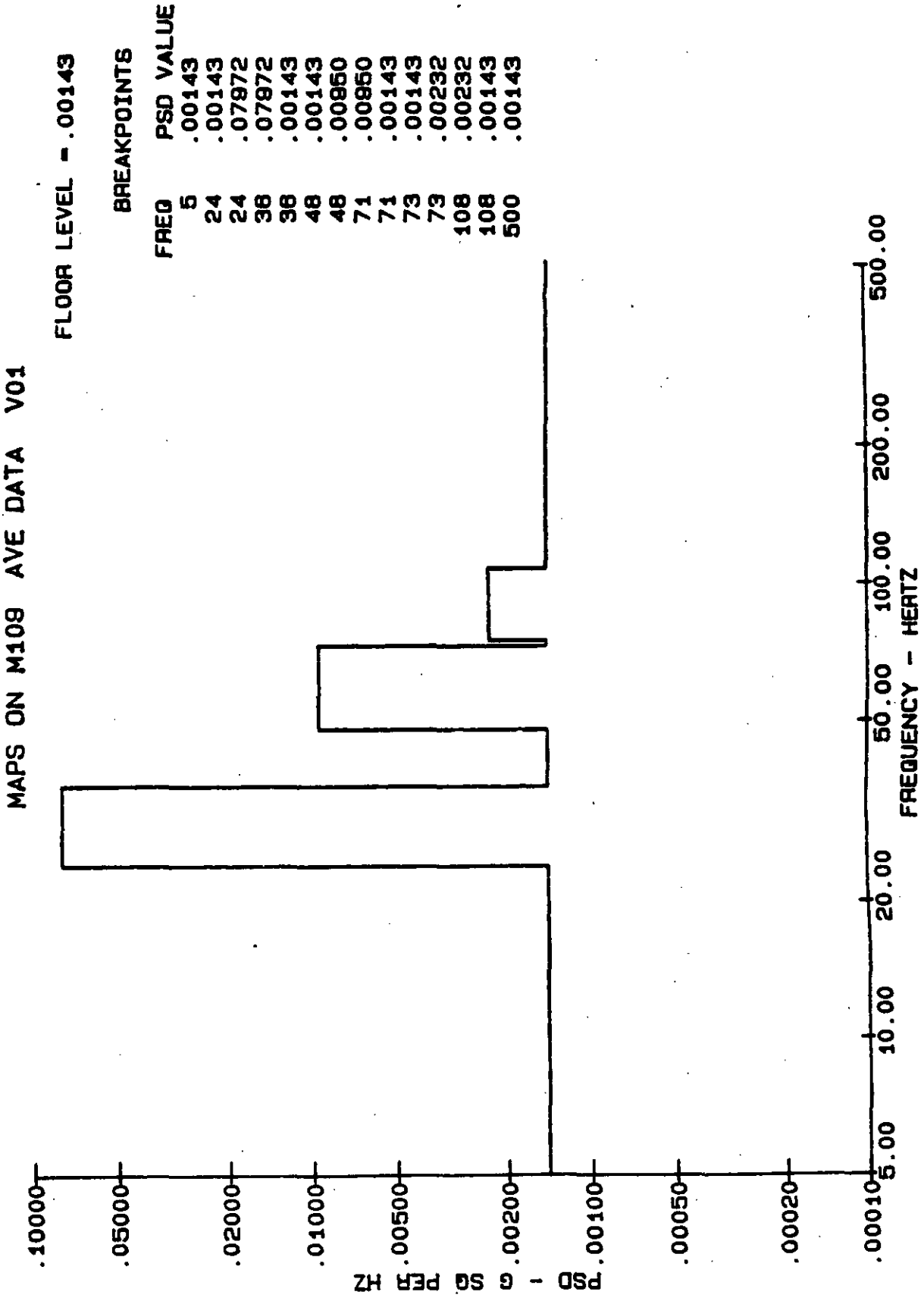
*** USE 2 SWEEPS AND 9 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 25 DB ***

APPENDIX H

RELIABILITY

VIBRATION TEST SCHEDULES



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 AVE DATA PHASE V01

TEST TIME, MINUTES: 12.0 DELTA F, HZ: 1.0 OVERALL RMS, G: 1.14

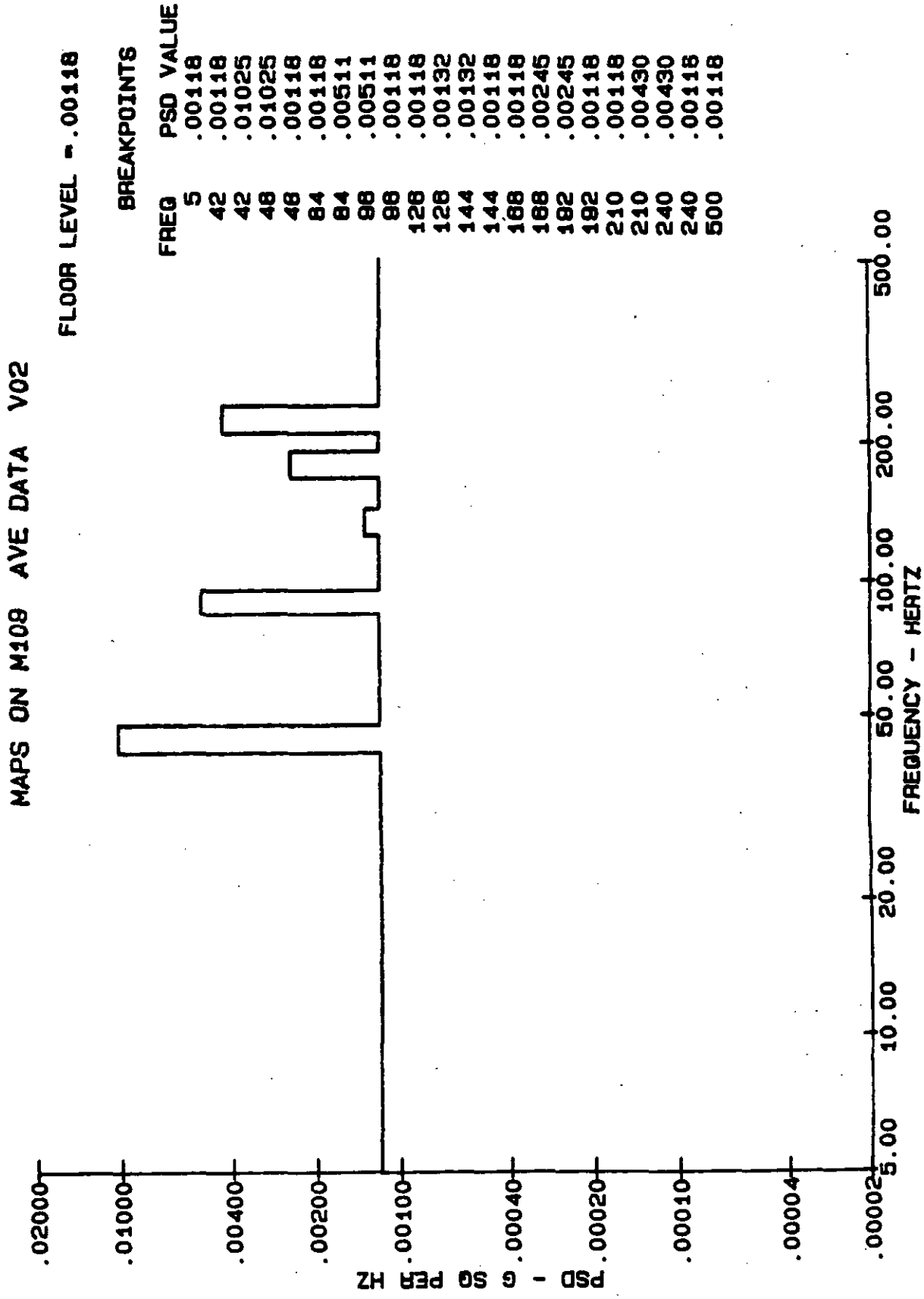
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
24.0	36.0	6.0	.07972	17.5
48.0	72.0	12.0	.00950	8.2
72.0	108.0	18.0	.00232	2.1
		FLOOR VALUES		
5.0	500.0	495.0	.00143	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
2	3
1	11

*** SET CONTROL WINDOW TO 20 DB ***

*** PEAK G VALUE EXPECTED: 5 SET CALIBRATION TO 500 MV/G ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 AVE DATA PHASE V02

TEST TIME, MINUTES: 12.0 DELTA F, HZ: 1.0 OVERALL RMS, G: .84

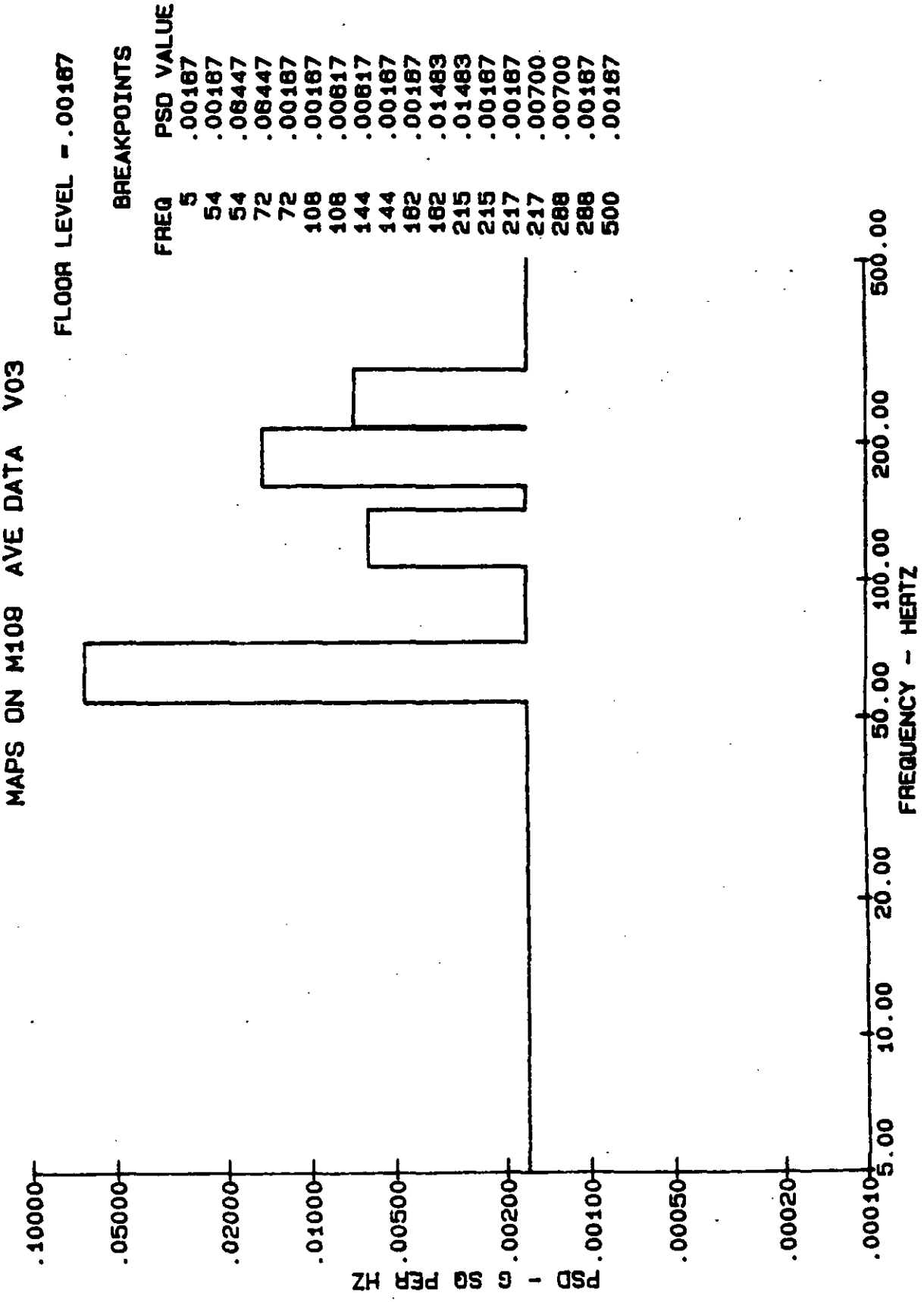
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
42.0	48.0	3.0	.01025	9.4
84.0	96.0	6.0	.00511	6.4
126.0	144.0	9.0	.00132	.5
168.0	192.0	12.0	.00245	3.2
210.0	240.0	15.0	.00430	5.6
		FLOOR VALUES		
5.0	500.0	495.0	.00118	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
3	1
2	4
1	14

*** SET CONTROL WINDOW TO 20 DB ***

*** PEAK G VALUE EXPECTED: 4 SET CALIBRATION TO 500 MV/G ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 AVE DATA PHASE V03

TEST TIME, MINUTES: 12.0 DELTA F, HZ: 1.0 OVERALL RMS, G: 1.42

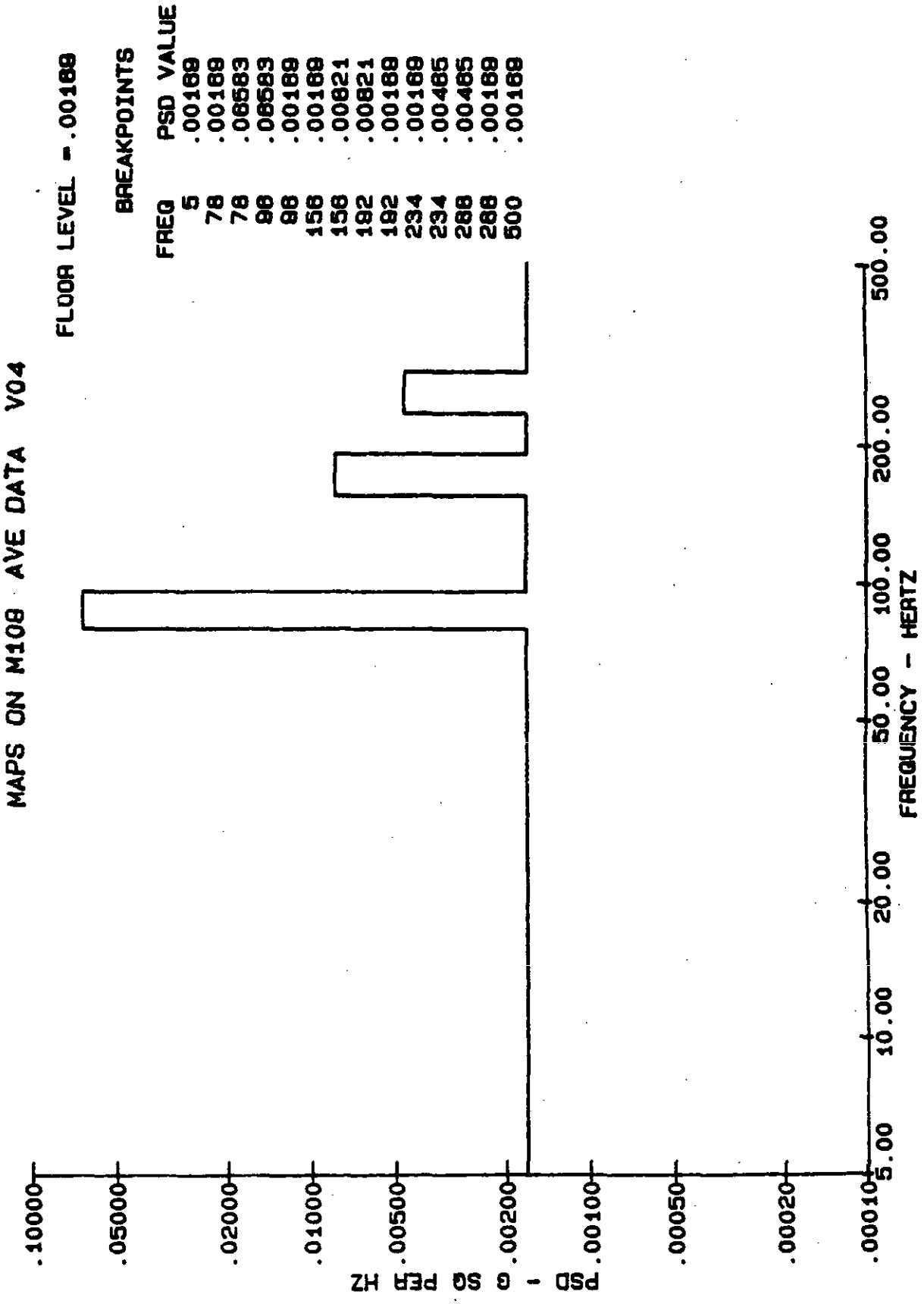
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
54.0	72.0	9.0	.06447	15.9
108.0	144.0	18.0	.00617	5.7
162.0	216.0	27.0	.01483	9.5
216.0	288.0	36.0	.00700	6.2
		FLOOR VALUES		
5.0	500.0	495.0	.00167	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
1	3

*** SET CONTROL WINDOW TO 20 DB ***

*** PEAK G VALUE EXPECTED: 6 SET CALIBRATION TO 500 MV/G ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 AVE DATA PHASE V04

TEST TIME, MINUTES: 12.0 DELTA F, HZ: 1.0 OVERALL RMS, G: 1.27

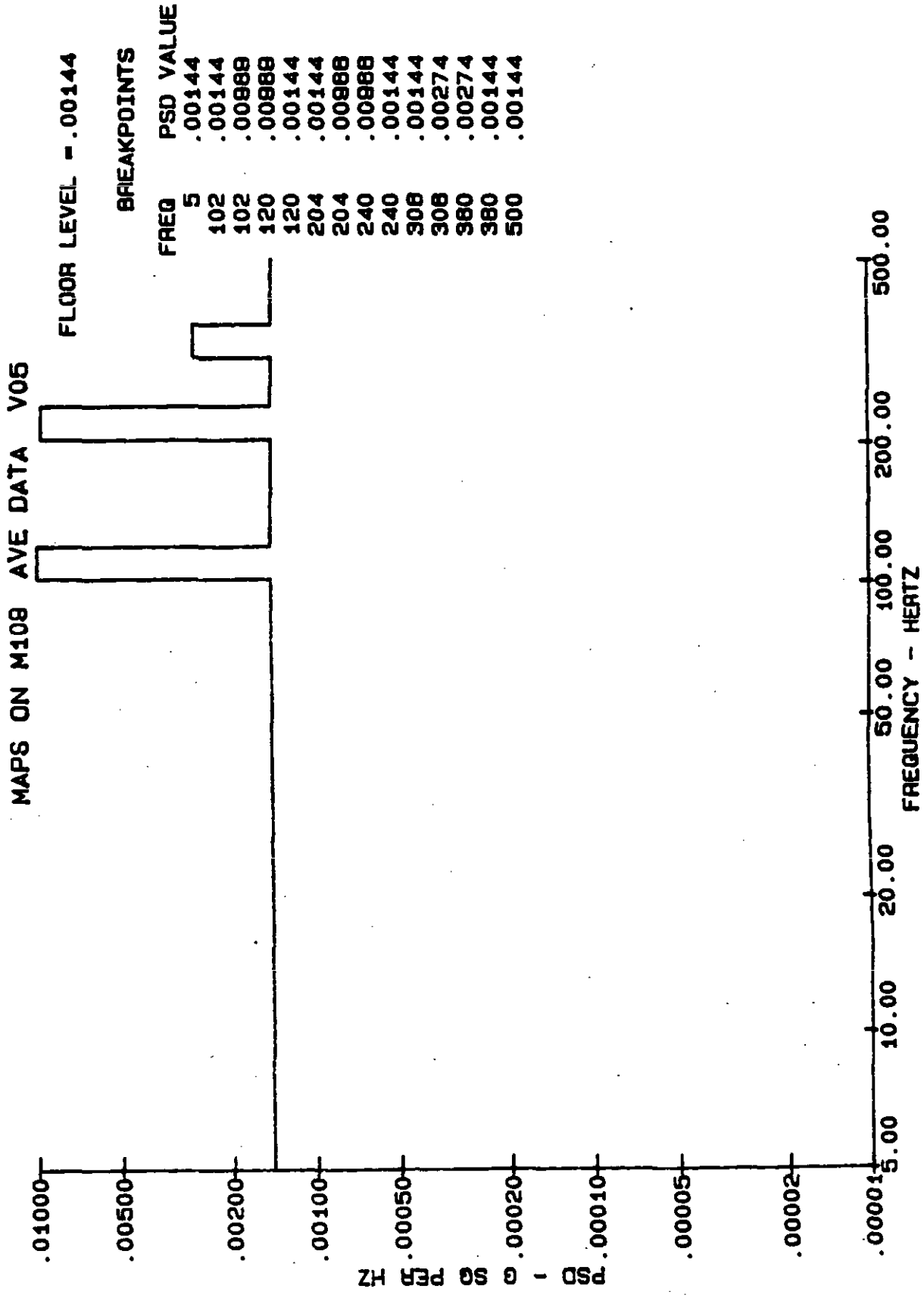
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
78.0	96.0	9.0	.06583	15.9
156.0	192.0	18.0	.00821	6.9
234.0	288.0	27.0	.00465	4.4
		FLOOR VALUES		
5.0	500.0	495.0	.00169	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
1	5

*** SET CONTROL WINDOW TO 20 DB ***

***PEAK G VALUE EXPECTED: 6 SET CALIBRATION TO 500 MV/G ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 AVE DATA PHASE V05

TEST TIME, MINUTES: 12.0 DELTA F, HZ: 1.0 OVERALL RMS, G: .99

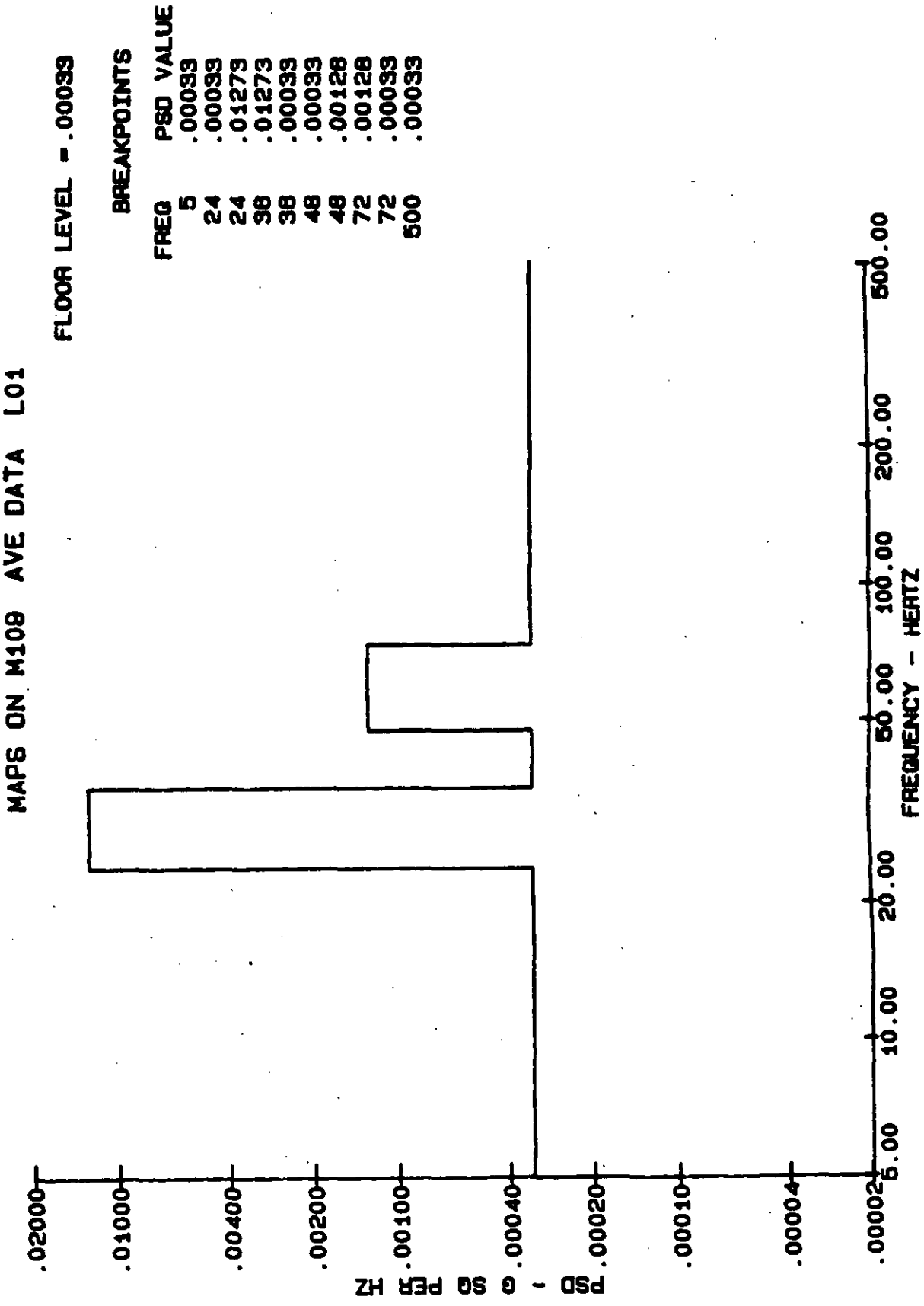
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
102.0	120.0	9.0	.00989	8.4
204.0	240.0	18.0	.00966	8.3
306.0	360.0	27.0	.00274	2.8
		FLOOR VALUES		
5.0	500.0	495.0	.00144	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
1	5

*** SET CONTROL WINDOW TO 20 DB ***

*** PEAK G VALUE EXPECTED: 5 SET CALIBRATION TO 500 MV/G ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 AVE DATA PHASE L01

TEST TIME, MINUTES: 12.0 DELTA F, HZ: 1.0 OVERALL RMS, G: .50

START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOO
24.0	36.0	6.0	.01273	15.9
48.0	72.0	12.0	.00128	5.9
		FLOOR VALUES		
5.0	500.0	495.0	.00033	

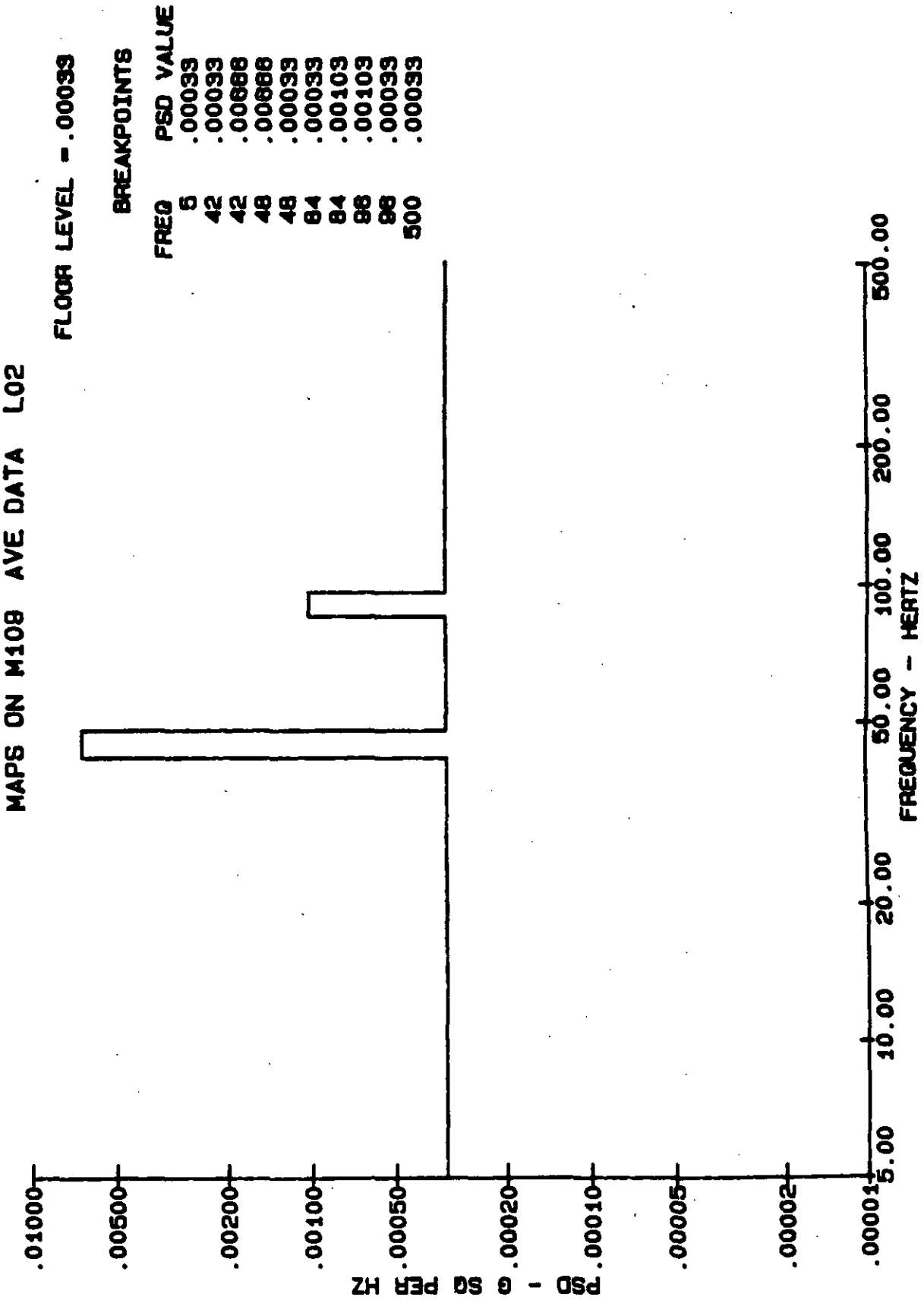
ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
4	1
3	3
2	7
1	18

*** USE 2 SWEEPS AND 7 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 20 DB ***

*** PEAK G VALUE EXPECTED: 3 SET CALIBRATION TO 500 MV/G ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 AVE DATA PHASE L02

TEST TIME, MINUTES: 12.0 DELTA F, HZ: 1.0 OVERALL RMS, G: .43

START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
42.0	48.0	3.0	.00666	13.0
84.0	96.0	6.0	.00103	4.9
		FLOOR VALUES		
5.0	500.0	495.0	.00033	

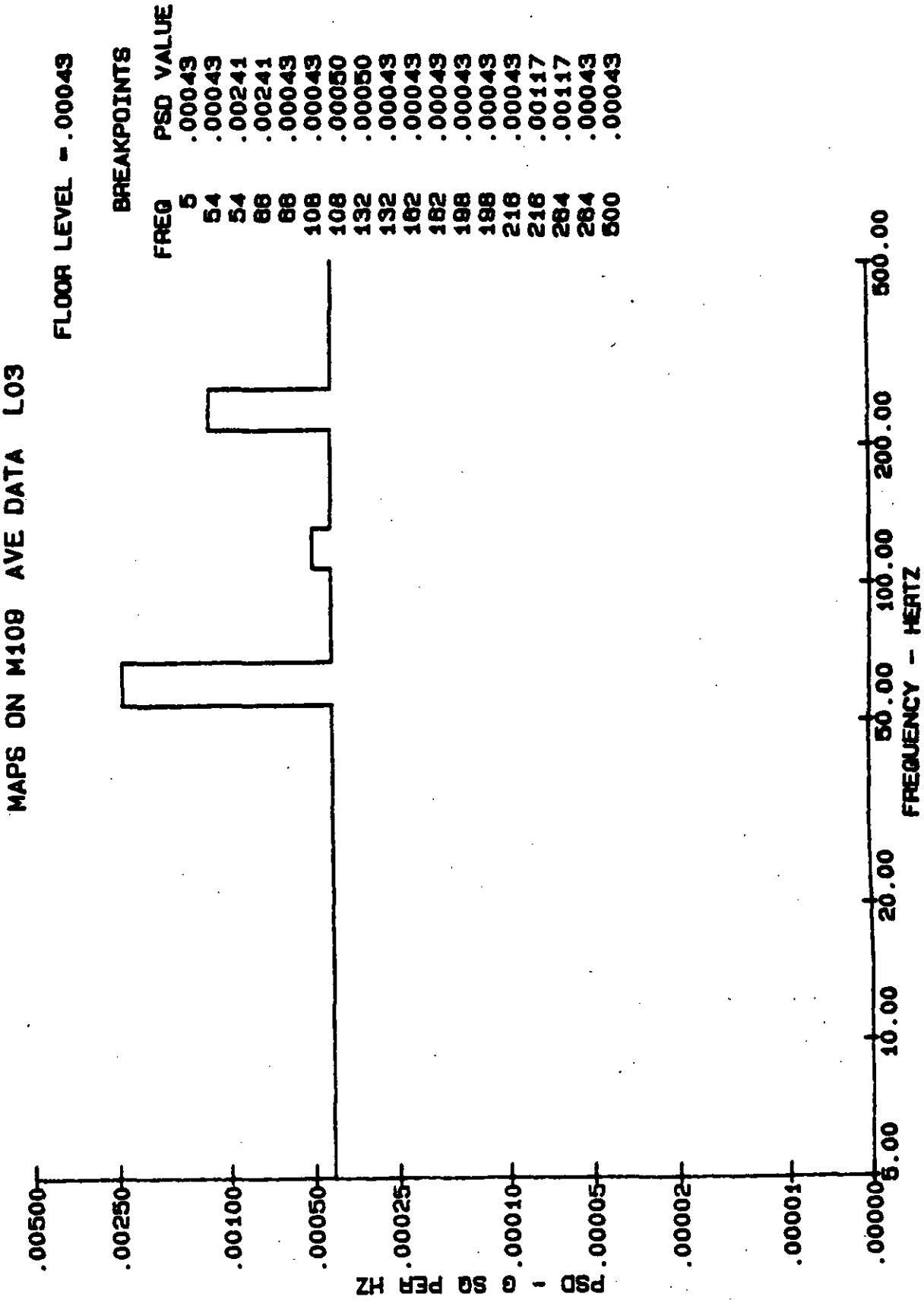
ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
8	1
7	2
6	3
5	4
4	7
3	11
2	18
1	20

*** USE 3 SWEEPS AND 11 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 20 DB ***

*** PEAK G VALUE EXPECTED: 2 SET CALIBRATION TO 500 MV/G ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 AVE DATA PHASE L03

TEST TIME, MINUTES: 12.0 DELTA F, HZ: 1.0 OVERALL RMS, G: .49

START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
54.0	66.0	6.0	.00241	7.5
108.0	132.0	12.0	.00050	.7
162.0	198.0	18.0	.00043	0.0
216.0	264.0	24.0	.00117	4.3

FLOOR VALUES

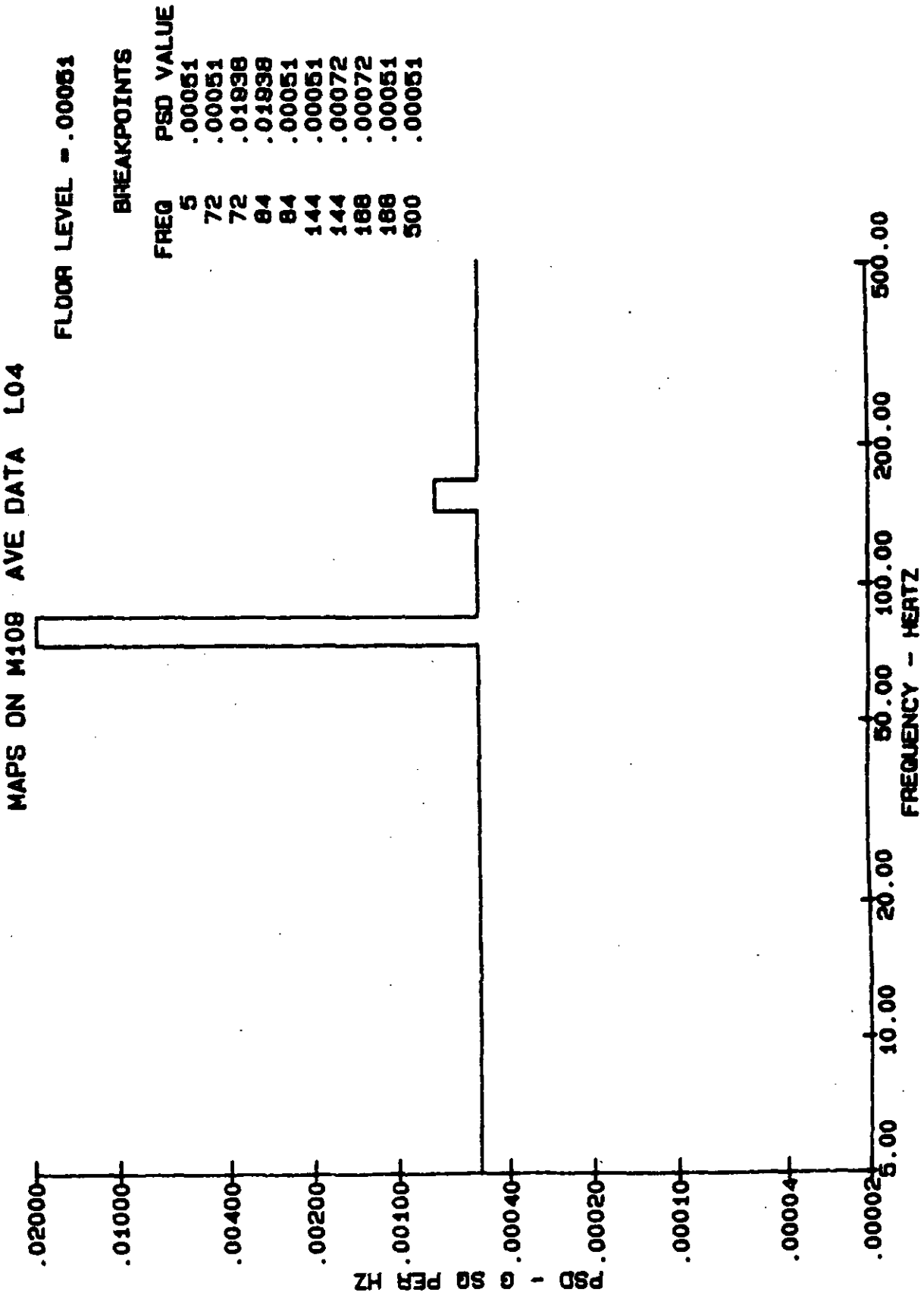
5.0	500.0	495.0	.00043

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
2	1
1	7

*** SET CONTROL WINDOW TO 20 DB ***

*** PEAK G VALUE EXPECTED: 3 SET CALIBRATION TO 500 MV/G ***



NARROW BAND RANDOM ON RANDOM SWEEP RATE PROGRAM

MAPS ON M109 AVE DATA PHASE L04

TEST TIME, MINUTES: 12.0 DELTA F, HZ: 1.0 OVERALL RMS, G: .61

START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
72.0	84.0	6.0	.01938	15.8
144.0	168.0	12.0	.00072	1.5
		FLOOR VALUES		
5.0	500.0	495.0	.00051	

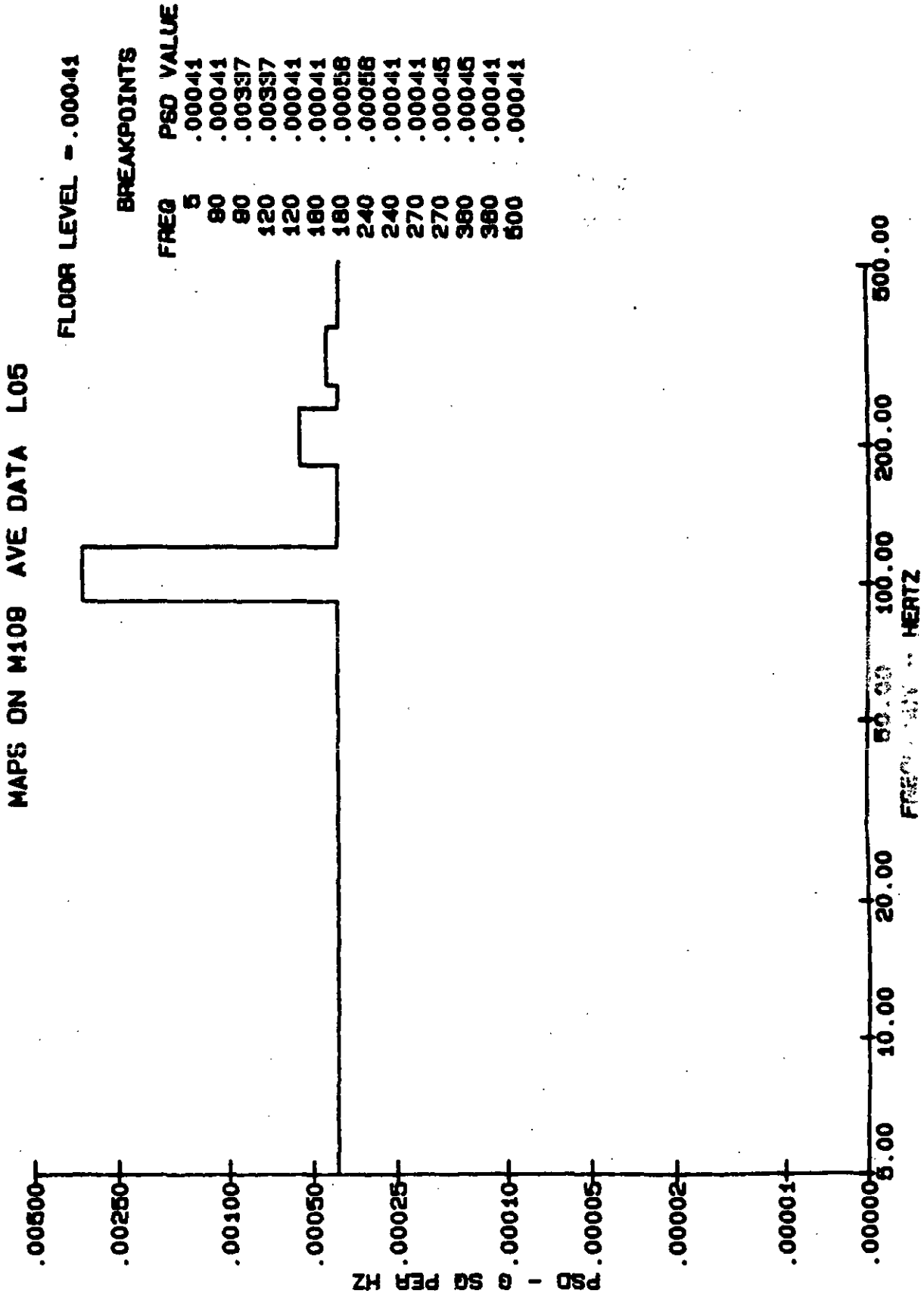
ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
4	1
3	3
2	7
1	18

*** USE 2 SWEEPS AND 7 AVERAGES PER LOOP ***

*** SET CONTROL WINDOW TO 20 DB ***

*** PEAK G VALUE EXPECTED: 3 SET CALIBRATION TO 500 MV/G ***



NARROW BAND RANDOM ON RAN : SWEEP RATE PROGRAM

MAPS ON M109 AVE DATA PHASE L05

TEST TIME, MINUTES: 12.0 DELTA F, HZ: 1.0 OVERALL RMS, G: .50

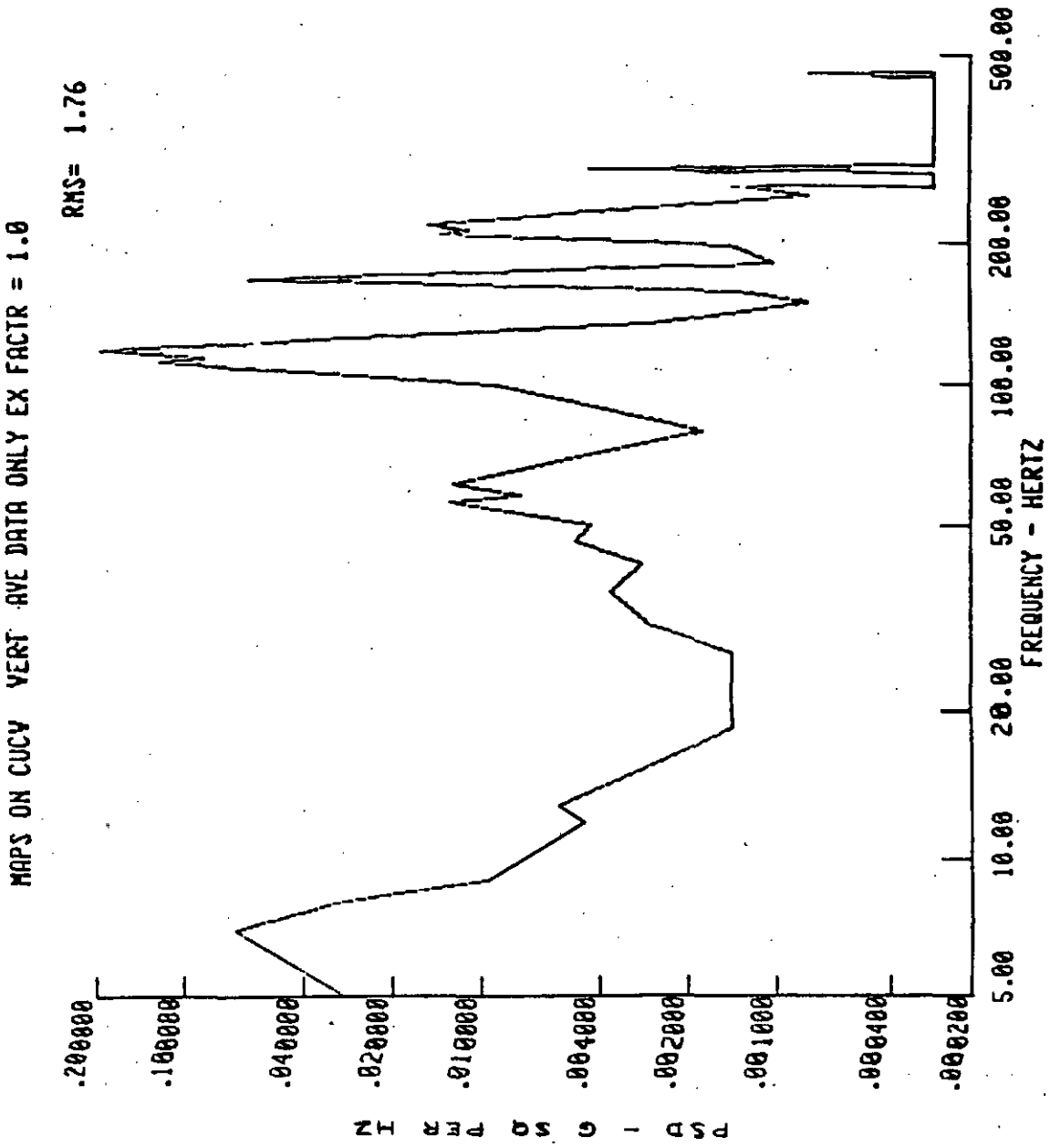
START FREQ	END FREQ	BAND WIDTH	PSD VALUE	DB RE FLOOR
90.0	120.0	15.0	.00337	9.1
180.0	240.0	30.0	.00056	1.4
270.0	360.0	45.0	.00045	.4
		FLOOR VALUES		
5.0	500.0	495.0	.00041	

ACCEPTABLE NUMBER OF SWEEPS AND NUMBER OF AVERAGES PER LOOP

SWEEPS	AVERAGES
1	1

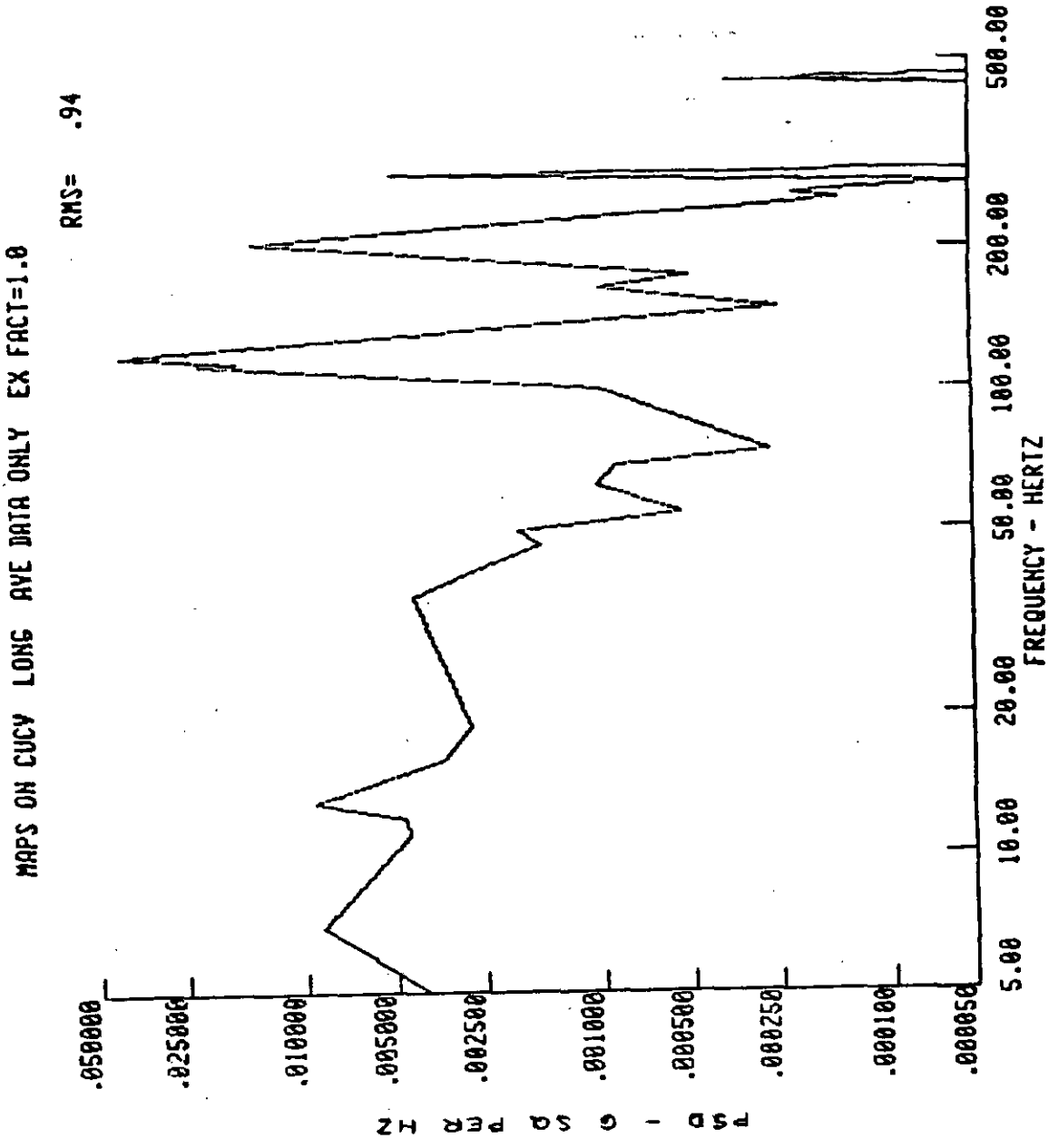
*** SET CONTROL WINDOW TO 20 DB ***

*** PEAK G VALUE EXPECTED: 3 SET CALIBRATION TO 500 MV/G ***



MAPS ON CUCV VERT. AVE. DATA EX. FACT. = 1.0

0001	39	NUMBER OF BREAK POINTS		
0002		5.00	.02950	FREQUENCY AND AMPLITUDE
0003		7.00	.06699	FREQUENCY AND AMPLITUDE
0004		8.00	.03101	FREQUENCY AND AMPLITUDE
0005		9.00	.00941	FREQUENCY AND AMPLITUDE
0006		12.00	.00446	FREQUENCY AND AMPLITUDE
0007		13.00	.00558	FREQUENCY AND AMPLITUDE
0008		19.00	.00139	FREQUENCY AND AMPLITUDE
0009		26.00	.00139	FREQUENCY AND AMPLITUDE
0010		30.00	.00265	FREQUENCY AND AMPLITUDE
0011		36.00	.00357	FREQUENCY AND AMPLITUDE
0012		42.00	.00285	FREQUENCY AND AMPLITUDE
0013		47.00	.00469	FREQUENCY AND AMPLITUDE
0014		51.00	.00414	FREQUENCY AND AMPLITUDE
0015		57.00	.01236	FREQUENCY AND AMPLITUDE
0016		59.00	.00716	FREQUENCY AND AMPLITUDE
0017		62.00	.01206	FREQUENCY AND AMPLITUDE
0018		80.00	.00174	FREQUENCY AND AMPLITUDE
0019		100.00	.00873	FREQUENCY AND AMPLITUDE
0020.		112.00	.11863	FREQUENCY AND AMPLITUDE
0021		115.00	.08378	FREQUENCY AND AMPLITUDE
0022		119.00	.19021	FREQUENCY AND AMPLITUDE
0023		135.00	.00265	FREQUENCY AND AMPLITUDE
0024		149.00	.00078	FREQUENCY AND AMPLITUDE
0025		157.00	.00135	FREQUENCY AND AMPLITUDE
0026		168.00	.06065	FREQUENCY AND AMPLITUDE
0027		180.00	.00103	FREQUENCY AND AMPLITUDE
0028		197.00	.00139	FREQUENCY AND AMPLITUDE
0029		209.00	.01332	FREQUENCY AND AMPLITUDE
0030		213.00	.01065	FREQUENCY AND AMPLITUDE
0031		219.00	.01471	FREQUENCY AND AMPLITUDE
0032		250.00	.00078	FREQUENCY AND AMPLITUDE
0033		262.00	.00142	FREQUENCY AND AMPLITUDE
0034		262.00	.00027	FREQUENCY AND AMPLITUDE
0035		281.00	.00027	FREQUENCY AND AMPLITUDE
0036		287.00	.00425	FREQUENCY AND AMPLITUDE
0037		293.00	.00027	FREQUENCY AND AMPLITUDE
0038		453.00	.00027	FREQUENCY AND AMPLITUDE
0039		457.00	.00078	FREQUENCY AND AMPLITUDE
0040		462.00	.00027	FREQUENCY AND AMPLITUDE
0041	RMS VALUE =	1.76		



MAPS ON CUCV LONG. AVE. DATA EX. FACT. = 1.0

0001	30	NUMBER OF BREAK POINTS		
0002		5.00	.00387	FREQUENCY AND AMPLITUDE
0003		7.00	.00878	FREQUENCY AND AMPLITUDE
0004		11.00	.00449	FREQUENCY AND AMPLITUDE
0005		12.00	.00460	FREQUENCY AND AMPLITUDE
0006		13.00	.00923	FREQUENCY AND AMPLITUDE
0007		16.00	.00342	FREQUENCY AND AMPLITUDE
0008		19.00	.00273	FREQUENCY AND AMPLITUDE
0009		35.00	.00427	FREQUENCY AND AMPLITUDE
0010		46.00	.00158	FREQUENCY AND AMPLITUDE
0011		50.00	.00188	FREQUENCY AND AMPLITUDE
0012		55.00	.00053	FREQUENCY AND AMPLITUDE
0013		63.00	.00101	FREQUENCY AND AMPLITUDE
0014		69.00	.00087	FREQUENCY AND AMPLITUDE
0015		74.00	.00027	FREQUENCY AND AMPLITUDE
0016		100.00	.00099	FREQUENCY AND AMPLITUDE
0017		113.00	.02202	FREQUENCY AND AMPLITUDE
0018		115.00	.01634	FREQUENCY AND AMPLITUDE
0019		119.00	.04099	FREQUENCY AND AMPLITUDE
0020		149.00	.00025	FREQUENCY AND AMPLITUDE
0021		163.00	.00099	FREQUENCY AND AMPLITUDE
0022		176.00	.00050	FREQUENCY AND AMPLITUDE
0023		207.00	.01443	FREQUENCY AND AMPLITUDE
0024		252.00	.00015	FREQUENCY AND AMPLITUDE
0025		260.00	.00022	FREQUENCY AND AMPLITUDE
0026		273.00	.00005	FREQUENCY AND AMPLITUDE
0027		287.00	.00508	FREQUENCY AND AMPLITUDE
0028		293.00	.00005	FREQUENCY AND AMPLITUDE
0029		444.00	.00005	FREQUENCY AND AMPLITUDE
0030		457.00	.00037	FREQUENCY AND AMPLITUDE
0031		466.00	.00005	FREQUENCY AND AMPLITUDE
0032	RMS VALUE =	.94		

Custodian:
Army - AR

Preparing activity:
Army - AR

(Project Number 1220-A368)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-D-70789 (AR)	DYNAMIC REFERENCE UNIT (DRU)

3a. NAME OF SUBMITTING ORGANIZATION

b. ADDRESS *(Street, City, State, ZIP Code)*

4. TYPE OF ORGANIZATION *(Mark one)*

- ☐ VENDOR
- ☐ USER
- ☐ MANUFACTURER
- ☐ OTHER *(Specify)*: _____

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

(TO DETACH THIS FORM, CUT ALONG THIS LINE.)