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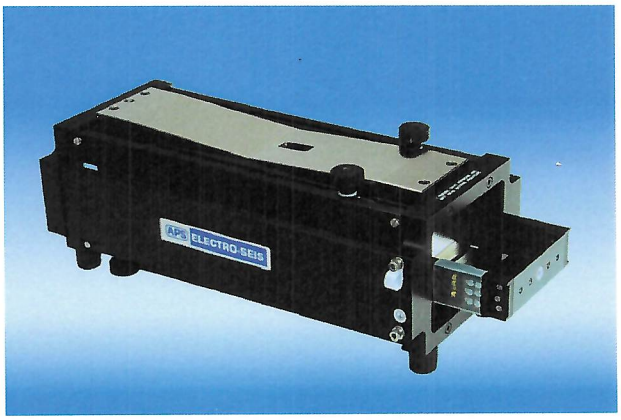
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INSTRUCTION MANUAL

ELECTRO-SEIS®

APS 113 SHAKER



CE

Serial Number:
2204

APS Dynamics
Systems for Generating Controlled Vibration
a subsidiary of SPEKTRA

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1 General Information

SCOPE

This Instruction Manual provides operation and maintenance information for the APS Dynamics ELECTRO-SEIS® Shaker APS 113, including HF and LZ versions, and applicable accessory items. Serial Number effectivity of this manual is given on the title page.

DESCRIPTION AND PURPOSE

The APS 113 ELECTRO-SEIS® Shaker is a long stroke, electrodynamic shaker, designed to be used alone or in arrays for exciting and studying the dynamic response characteristics of structures in the seismic frequency range. Its design has been optimized specifically for driving structures at their natural resonance frequencies, delivering maximum power to such resonant loads, with minimum total shaker weight and drive power.

The APS 113 provides modal test excitation of such complex structures as piping systems, electrical substation structures and apparatus, floors, missiles, aircraft, spacecraft, etc. To accommodate a wide variety of structures and test configurations, the shaker is capable of operating in four modes: fixed body, free body, free armature, and shaker table mode. Its thrust axis may be oriented at any angle between vertical and horizontal, with no degradation of performance. A linear bearing/shaft system provides high lateral load capability and an adjustable, high compliance axial suspension system provides for a variety of load/shaker support configurations.

The unit employs permanent magnets and is configured such that the armature coil remains in a uniform magnetic field over the entire stroke range. Drive power for the shaker is obtained from a power amplifier, such as the APS 125.

The shaker can be used with various optional accessory items to extend the areas of application.

1. APS 0052 0077 - AUXILIARY TABLES – extend the application of the shaker to vibration of such items as components and model buildings.
2. APS 0108 - CARRYING HANDLES & TIE-DOWN BARS – provides convenient portability and tie-downs.

NOTES

3. APS 0112 - REACTION MASS ASSEMBLY – allows either horizontal or vertical generated force to be applied through the shaker body to a horizontal surface on which the shaker is placed.

For more detailed information refer to the "Accessory Information" in Section 1.

NOTES

CHARACTERISTICS AND PERFORMANCE PARAMETERS

Frequency Range ..... 0 Hz to 200 Hz

Force Rating APS 113, APS 113-LZ (continuous)
- dc to 0.1 Hz ..... 94 N (21 lb) peak
- Above 0.1 Hz ..... 133 N (30 lb) peak
- Above 20 Hz ..... Refer to Figure 3-7

Force Rating APS 113-HF (50 % Duty Cycle – 1/2 hr)
- dc to 0.1 Hz ..... 133 N (30 lb) peak
- Above 0.1 Hz ..... 186 N (42 lb) peak
- Above 20 Hz ..... Refer to Figure 3-7

Maximum Stroke ..... 158 mm (6.25 in) pk-pk

Velocity ..... 1,000 mm/s (39 in/s)

Armature Weight, Typical ..... 2.27 kg (5.0 lb)
(Refer to Section 5 Calibration)

Rated Current, Typical APS 113 ..... 3.5 A RMS
Rated Current, Typical APS 113-LZ ..... 7 A RMS
Rated Current, Typical APS 113-HF ..... 8 A RMS
(Refer to Section 5 Calibration)

Load Attachment ..... Clearance hole for 6 mm (1/4 in) rod

Accelerometer/Component
- Attachment ..... 4 each 10-32 threaded holes

Outline and Installation
- Dimensions ..... Refer to Figure Section 5

Weights
- Body ..... 35 kg (78 lb)
- Total Shaker ..... 38 kg (83 lb)

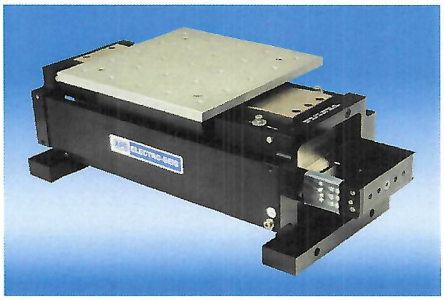
Environmental
- Operating Temperature ..... 5 to 40 degrees C
- Storage Temperature ..... -40 to 85 degrees C
- Humidity ..... 80 % RH Maximum

ACCESSORY INFORMATION

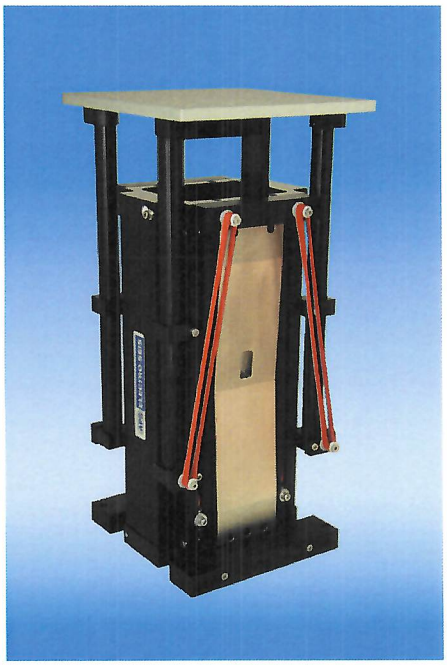
APS 0052 0077 0078 - AUXILIARY TABLES

The APS 0052 0077 - Auxiliary Tables attach to the armature support points on the shaker and provide mounting platforms for supplying transverse and axial base excitation to such test items as components, model structures, accelerometers, accelerographs, and other low frequency instrumentation.
Refer to Section 5 for installation drawings. The APS 0078 provides all parts required for either configuration.

Static and dynamic loads from the table and test item are transferred directly to the shaker's internal guidance and suspension systems. The table and guidance bearing system are rated to support up to 23 kg (50 lb) maximum test loads weight. The shaker's internal suspension system may be adjusted to center the armature and table within the stroke range for all orientations.



APS 0052 - Auxiliary Table



APS 0077 - Auxiliary Table

CHARACTERISTICS AND PERFORMANCE PARAMETERS

Armature weight (including four bearing housing clamps) ..... 2.5 kg (5.5 lb)

Armature weight including horizontal table (APS 0052) ..... 5.4 kg (11.9 lb)

Armature weight including vertical table (APS 0077) ..... 5.8 kg (12.8 lb)

Table Size ..... 254 x 254 mm (10 x 10 in)

Load Attachment Holes
- Metric option ..... 25 ea M6 on 50-mm centers
- Imperial option ..... 25 ea 1/4-20 on 2-in centers

Load Attachment Thread Size
- Metric option ..... M6 x 1
- Imperial option 1/4-20

Maximum Test Load Weight
- Horizontal ..... 23 kg (50 lb)
- Vertical ..... 11 kg (25 lb)

NOTES

APS 0108 - CARRYING HANDLES AND TIE-DOWN BARS

This kit provides convenient portability and tie-down in both a horizontal and vertical mode. Refer to Section 5 for installation drawing.

APS 0109 - ZERO POSITION CONTROLLER

The APS 0109 - Zero Position Controller automatically controls the zero position of a vibration exciter irrespective of its load. The APS 0109 is intended for the automatic control of vibration systems with integrated power amplifiers that supply an offset-free DC voltage such as the APS 125 and APS 145.

APS 0112 - REACTION MASS ASSEMBLY

Two Reaction Mass Blocks attach to the armature support points on the shaker and provide sufficient reaction mass to obtain rated force down to 1.8 Hz in a free armature mode. Refer to Section 5 for installation drawing.

The Reaction Mass Suspension System may be adjusted to center the Armature and Reaction Mass within the stroke range for all orientations of its force axis. Handles provide a convenient means for carrying the unit. A handle diagonally interchanged with one of the feet extension bars allows horizontal placement of the shaker force axis.

CHARACTERISTICS AND PERFORMANCE PARAMETERS

Armature weight including Reaction Mass..... 13.2 kg (29 lb)

Minimum frequency for 30 lb Force .....1.8 Hz

Total Shaker Weight including Reaction Mass ..... 47 kg (103 lb)

APS 0414 - LIFTING HANDLES

This kit provides convenient portability in combination with the accessories APS 0112 or APS 0078. Refer to Section 5 for installation drawing.

APS 8610 - MODAL STINGER KIT

This accessory provides a connection between the shaker armature and a test structure via a modal stinger. The kit consists of three modal stingers in different lengths. The Modal Stingers are designed to deliver an axial force to the test structure and to help decouple cross-axis force inputs.

APS 8611 - STEEL CABLE KIT

This accessory provides four sets of suspension lines to use the shaker in free body - pendulously suspended mode.



APS 0108 - Carrying Handles & Tie-down Bars



APS 0112 - Reaction Mass Assembly with additional APS 0414 Lifting Handles 0414

2 Preparation for Use

UNPACKING AND HANDLING

The APS 113 ELECTRO-SEIS® Shaker is shipped in a heavy duty, wooden box. Within the box the unit is secured and protected by foam blocks. The box and packing material should be retained for shipment of the APS 113 to test sites or for extended storage periods.

* CAUTION *

THE APS 113 SHAKER CONTAINS A BALANCED MAGNETIC CIRCUIT. HOWEVER, THE SMALL STRAY FIELD NEAR THE UNIT CAN AFFECT WATCHES AND OTHER DELICATE MECHANISMS. KEEP SUCH OBJECTS AT LEAST A FOOT AWAY FROM THE SHAKER.

The unit weighs approximately 38 kg (83 lb) and may be lifted by using the end frames as hand holds or by installing four eyebolts in the upper body support points and lifting with a light hoist.

In addition to the basic shaker, the shipping box contains:

1. Instruction manual
2. Optional suspension bands

Four rubber feet are installed on the bottom of the shaker for normal resting on horizontal surfaces. The feet are secured to the end frames of the body by 1/4-20 socket head cap screws. The feet may be removed if the unit is to be attached to certain accessories or a specialized mounting fixture. Refer to Section 5, Outline Drawing APS 113.

* CAUTION *

IF FEET ARE REMOVED, BE SURE UNIT DOES NOT REST ON SUSPENSION ADJUSTMENT SLIDE KNOBS. THESE KNOBS PROJECT BELOW THE PLANE OF THE MAGNET STRUCTURE'S LOWER SURFACE.

NOTES

PREPARATION FOR USE

The unit is completely assembled when shipped. Light suspension bands are installed in the shaker, and the suspension system is adjusted to retain the armature against its inner stops. Prior to operating the unit, adjust the internal suspension for mid-position of the armature relative to the magnet structure. To accomplish this, loosen the upper suspension knobs and slide in the direction of the desired armature movement. Retighten the knobs.

Manually displace the armature over its stroke range to verify free operation of the bearings and free running of the coil in the magnetic air gap. Check the armature leads for free rolling action.

The APS shakers consist of a junction box, that consolidates all of the cabling interfaces (power, ground, current control and as an option: over-travel control, temperature control, etc.) into one location with a single cable interface (electrical input). Refer to Section 5 for detailed information.

Attach the connecting cable with one 8-pin plug to the electrical input located on the junction box on the side of the shaker. Refer to Section 5 for installation drawing. When using the APS 125 or APS 145 amplifier, connect the second 8-pin plug of the connecting cable to the amplifier-output.



WARNING

WHEN OPERATING SHAKER, ENSURE THAT PERSONS, DOMESTIC ANIMALS, AND PROPERTY (OTHER THAN PROPERTY INVOLVED IN TESTING) ARE NOT ADJACENT TO MOVING ARMATURE.

SUSPENSION SYSTEM ADJUSTMENT

The APS 113 Shaker's internal suspension system uses high strength silicone bands in several possible arrangements to support external static loads. The bands act in tension between attachment points on the armature and body. The configuration of the suspension system allows the ends of the bands attached to the body to be shifted along the axis of the shaker to accommodate different static loads and return the armature/body neutral position to the center of the relative stroke range. Always use maximum stretch possible consistent with the above adjustment. The available range of adjustment is extended by using different numbers of the light or heavy bands provided with the unit.

NOTES

The recommended configurations of the suspension bands for other modes of operation are given in Figure 2-1.

In order to change the band configuration or type, perform the following steps:

1. If the bands to be changed are in the lower half of the shaker, place the shaker in a vertical orientation resting on its rear end frame. Place it on its feet in the horizontal orientation for changing bands in the upper half.
2. Loosen the suspension slide knobs and allow the bands to return to minimum elongation. When opposing bands are used, the knobs will be in the middle position along the shaker axis.
3. Remove the appropriate corner covers to allow access to the band attachment points. To remove a corner cover, first loosen the knurled, captive screw at each end, and then slide the cover outwardly in the end frame channels.
4. Remove the bands from the suspension slide pins first, and then remove them from the armature pins.
5. To replace the bands, reverse the above procedure, always locating the wide section of the bands over the support pins. Note that the suspension slide may be locked in any position along the suspension slide guide with the corner cover removed. When replacing the corner cover, be sure that the Nylon washer under the knob is not obstructing the cover from sliding into its correctly installed position. *DO NOT over-tighten the knurled, captive screw.*

ATTACHMENT OF SHAKER TO TEST STRUCTURES USING THRUST RODS

For structural excitation employing the fixed body and free body - pendulously suspended modes, a thrust rod like the APS 8610 - Modal Stinger can be used to connect the shaker armature to the drive point on the structure. Used in lengths of several inches or more, it offers a degree of cross-axis compliance to accommodate curvilinear shaker/structure motion and make alignment of the shaker and drive point less critical.

PREPARATION FOR STORAGE OR RESHIPMENT

The shaker is best stored or shipped in its original shipping container, sealed against moisture in a plastic bag. The internal suspension should be adjusted to displace the armature to its innermost position.

NOTES

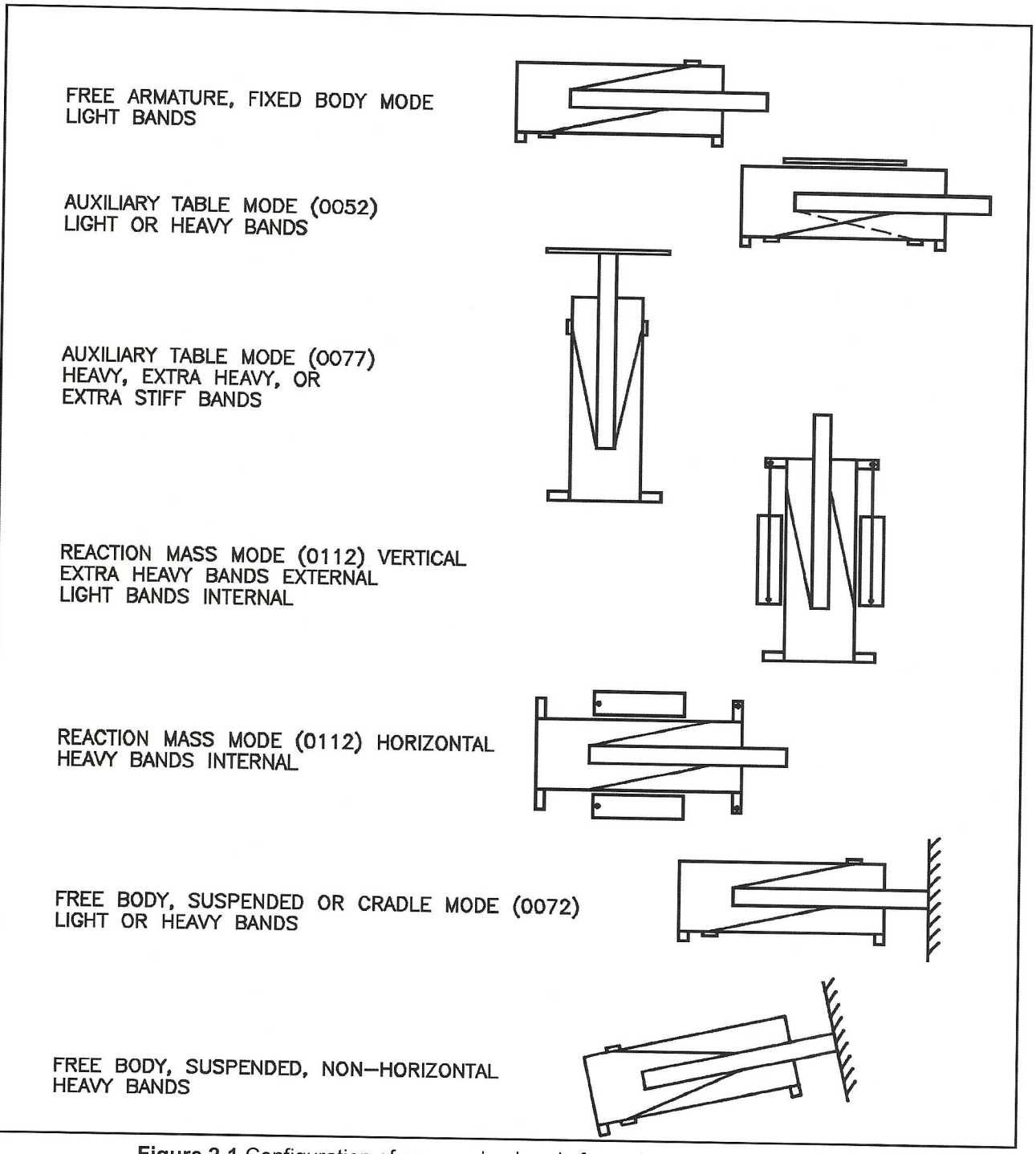
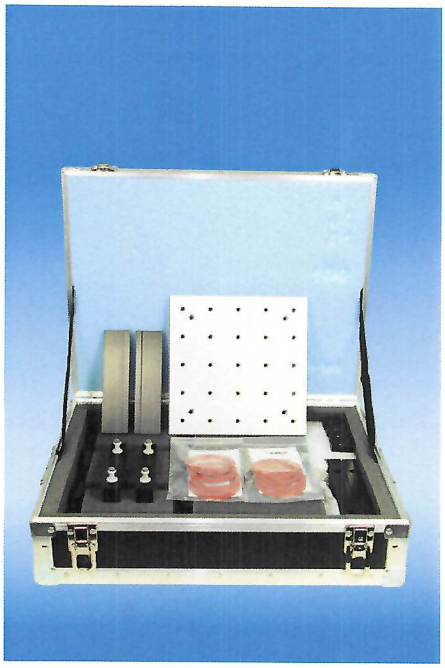


Figure 2-1 Configuration of suspension bands for various modes of operation

ACCESSORY INFORMATION

The relevant installation drawings in Section 5, contain lists of all replaceable parts for the following accessories.

Each accessory is packaged in a storage box, complete with all parts and tools required for installation, a laminated installation drawing and a specific manual.



APS 0078 - Auxiliary Tables, Packing, Storing, and Reshipping container

APS 0052 0077 0078 - AUXILIARY TABLES

For installation, please refer to the manual of the APS 0052 0077 0078 - Auxiliary Tables provided with the accessory.

APS 0108 - CARRYING HANDLES AND TIE-DOWN BARS

The APS 0108 - Carrying Handles and Tie-Down Bars are shipped in a separate container and are installed by the user.

The following procedure provides instructions for attaching the Feet Extension Bars and Carrying Handles to the shaker body:

1. Place the shaker in a vertical position.
2. Remove the four rubber feet supplied with the APS 113 and store for future use.
3. For vertical orientation of the shaker, attach the Feet Extension Bars and Carrying Handles with the eight Socket Head Cap Screws referenced in the installation drawing.
4. For horizontal orientation of the shaker, attach the Feet Extension Bars and Carrying Handles with the eight Socket Head Cap Screws referenced in the installation drawing.

In operation the shaker may be placed on a flat surface using the non-skid backing to resist slipping of the shaker body.

NOTES

APS 0109 - ZERO POSITION CONTROLLER

For installation, please refer to the manual of the APS 0109 - Zero Position Controller provided with the accessory.

APS 0112 - REACTION MASS ASSEMBLY

For installation, please refer to the manual of the APS 0112 - Reaction Mass Assembly provided with the accessory.

APS 0414 - LIFTING HANDLES

The APS 0414 - Lifting Handles are shipped in a separate container and are installed by the user.

For installation, please refer to the installation drawing in Section 5 or to the laminated installation drawing provided with the accessory.

APS 8610 - MODAL STINGER KIT

For installation, please refer to the Installation Guide provided with the accessory.

APS 8611 - STEEL CABLE KIT

For installation, please refer to the Installation Guide provided with the accessory.

NOTES

3 Principles of Operation

THEORY OF OPERATION

FORCE GENERATION

The APS 113 ELECTRO-SEIS® Shaker is fundamentally a force generator. Its basic operating principle is that of force generation in a current carrying conductor, located in a dc magnetic field which is perpendicular to the direction of the current. See Figure 3-1.

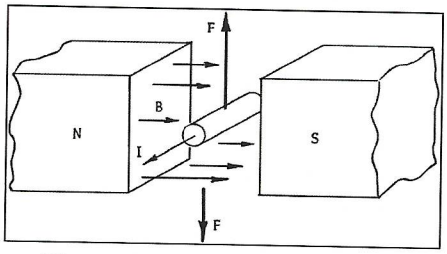


Figure 3-1 Principle of electro-dynamic force generation

In Figure 3-1, N and S are north and south poles of the magnet creating flux density, B, in the air gap. Force, F, is generated and acts on the conductor carrying current, I. The magnitude of the generated force is directly proportional to the instantaneous value of current, and the force acts in a direction mutually perpendicular to the directions of current and magnetic field.

Corresponding to the force generated on the current carrying conductor and associated armature structure, there is an equal and oppositely directed reaction force, F, developed on the magnetic field structure or body of the shaker. The APS 113 Shaker is thus capable of generating any time waveform of force acting between its armature and body, in accordance with an identical time waveform of current supplied to it. The force magnitude is directly adjustable, independent of the frequency or time waveform of operation, and it may be instantaneously terminated by interrupting the current.

For a given force, the relative motion which results between the armature and body of the shaker is a function of the mechanical impedance of the structures to which the two portions of the shaker are attached. That is, for a given current a resultant force will be produced whether either or both the armature and body are blocked or free, or loaded to any degree between these extremes.

NOTES

MAXIMUM FORCE AND CURRENT RATINGS

The continuous duty force rating of the APS 113 is dictated by the maximum allowable temperature rise of the natural convection cooled armature coil. This establishes a maximum electrical power dissipation and corresponding force and nominal current limits of 94 N (21 lb) RMS and 3.5 A RMS. Therefore, for continuous sinusoidal operation above 0.1 Hz, the maximum ratings are 133 N (30 lb) peak and 5 A peak.

For sinusoidal operation between dc and 0.1 Hz, where the period of the current waveform is long compared to the thermal time constant of the armature coil, the maximum ratings are 94 N(21 lb) peak and 3.5 A peak (0.707 times the higher frequency values).

Above 20 Hz, because of an increasing voltage requirement, force may be limited to less than the maximum rating depending on the amplifier capability.

Refer to performance envelopes in Figures 3-7 and 3-8. The APS 113-HF has an intermittent force rating of 186 N (42 lb) with a 50 % duty cycle over a 1/2 hour period.

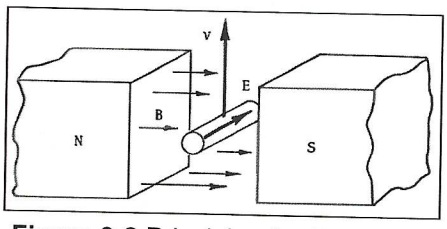


Figure 3-2 Principle of velocity voltage generation

NOTES

MAXIMUM STROKE

Many structures have resonance frequencies which lie in the 1 Hz to 20 Hz frequency region. Their resonance frequencies are low by virtue of their large dimensions and/or corresponding low Stiffness/mass ratio. While vibrating at resonance, the antinodes or points of maximum deflection on such structures can execute displacements exceeding an inch, and yet the stresses remain well below the elastic limit. Since the most efficient drive point on a resonant structure is at or close to the antinode of the mode being excited, a low frequency range modal shaker should therefore have sufficient stroke capability to accommodate such load displacements. Furthermore, as discussed below, the stroke range must also accommodate significant motion of the shaker body, to develop force at low frequencies when operating in a free body mode. For these reasons, the APS 113 Shaker has a 158-mm (6.25-in) peak-to-peak relative stroke capability. The ELECTRO-SEIS® series of shakers are designed so that linear force is developed at any point within the stroke range.

MOTIONAL IMPEDANCE

When a relative velocity occurs between the shaker body and armature/test structure, an electromotive force or voltage is generated along that portion of the armature coil conductor which lies in the magnetic field. See Figure 3-2. As before, N and S are north and south poles of the magnet creating flux density, B, in the air gap. Induced voltage E, is generated along the conductor as a result of the relative velocity, v, between the conductor and magnetic field. The arrow, E, indicates the direction of generated voltage rise.
The magnitude of the induced voltage is directly proportional to the instantaneous value of relative velocity; its polarity is such as to oppose the external voltage that was applied to circulate the force-producing current. For this reason it is sometimes termed "velocity voltage" or "back emf". Thus through electrodynamic action, the mechanical motion produces an additional electrical voltage drop in the armature circuit. This "motional" impedance adds vectorially to the

inherent electrical impedance of the circuit.
Therefore, to establish a given current and corresponding force, the power amplifier must generally supply more voltage when that force produces a relative velocity, than would be the case if the armature and body were blocked and remained motionless.

NOTES

RESONANT LOAD DRIVE REQUIREMENTS

The mechanical input impedance of a drive point on a test structure is defined as the ratio of the applied force to the resulting absolute velocity at that point. In the vicinity of structural resonances, this impedance varies widely in magnitude and associated phase angle as frequency is varied. At resonance, its magnitude is low, and it appears resistive; at frequencies off resonance, its magnitude is relatively greater, and it appears predominantly reactive (spring-like or mass-like). When viewed in terms of reflected motional impedance in the armature electrical circuit, the low resistive mechanical impedance at resonance reflects as a high electrical resistance; the greater mechanical impedance off resonance reflects a smaller reactive electrical impedance. Thus, for a given force, the shaker's electrical power requirements are generally greater when driving a structure at resonance than when driving off resonance.

At resonance, a large amount of reactive kinetic and potential energy is contained in a structure, and the driving amplifier and shaker must accommodate the resulting velocity and displacement.
This reactive energy is introduced and stored during the transient build-up of the structure's resonant response, and it alternates back and forth between kinetic and potential forms twice during each cycle of vibration. However, to sustain the resonant vibration level after the transient build-up period, the amplifier and shaker need only supply to the structure the real mechanical power dissipated by damping mechanisms within the structure.

MATCHED RESONANT LOAD

If a drive point on a structure in resonance is vibrating with a velocity of 1,000 mm/s (39 in/s), and a force of 133 N (30 lb) is required to sustain the vibration level, then the shaker will be delivering approximately 65 W to the structure. Since these are the maximum ratings of the APS 113 Shaker, such a load is termed the matched resonant load for the shaker. It is resistive, since the load force and velocity are in phase at resonance. From a maximum power transfer standpoint therefore, the shaker should also dissipate approximately 65 W, and the total real power required from the driving amplifier would be approximately 130 W. The APS 113 Shaker design is optimized in this manner.

MODES OF OPERATION

GENERAL

The APS 113 Shaker is a versatile source of mechanical force for long stroke, low frequency excitation. With its body mounted on a rigid bench or floor, the shaker may be used to support and vibrate loads attached to its armature in a shaker table mode. Auxiliary tables are available for such applications. Refer to the "Accessory Information" in Section 1 of this manual. Its primary application, however, is in the excitation of resonant modes of large structures. To accommodate a diversity of resonance or modal test configurations, the shaker has been designed specifically to operate in three primary modes. These modes are termed: Fixed Body, Free Body, and Free Armature.



Figure 3-3 APS 113 Shaker in Fixed Body Mode

FIXED BODY MODE

In the Fixed Body Mode, the shaker body is fixed and the armature is attached to the test structure.Refer to Figure 3-3. In this mode, force delivered to the test structure can be measured by inserting a force transducer in the thrust linkage between the armature and test structure. Alternatively, with the armature/body suspension bands removed, shaker current can be used as a direct measure of the generated force. The generated force is approximately equal to the force delivered to a resonant test structure, because the armature mass is typically small compared to the modal mass of most large test structures. Furthermore, the small component of force acting to accelerate the armature is in quadrature with the force delivered to the damping of the resonant structure.

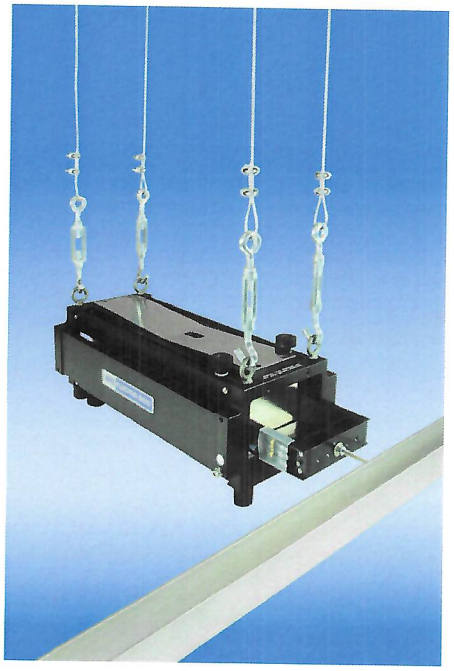


Figure 3-4 APS 113 Shaker pendulously suspended by cables

FREE BODY MODE

The desired force input points on many test structures lie at a considerable distance above ground level. For tests on such items, it becomes difficult and expensive to design, build, and use Fixed Body Mode support structures which remain non-resonant over the frequency range of interest. For such applications, the Free Body Mode can be employed to advantage. In this mode the shaker body is used as the reaction mass by suspending the shaker from an overhead support. Refer to figure 3-4.
In the Free Body Mode, force delivered to the test structure can be measured by inserting a force transducer between the armature and structure. Also, as before, armature current may be used, but only at frequencies well above the suspension resonance frequency. It does not provide an accurate measure of the force delivered to the armature and load at very low frequencies. However, a very convenient measure of the load force is the axial acceleration of the shaker body. As stated before, the mass of the armature is typically small relative to the modal mass of most large structures, and the

force required to accelerate it acts in quadrature with the force delivered to the structural damping. Neglecting this small force component, the net force acting on the resonant structure is equal to the net force acting on the shaker body as measured by the body mass and acceleration, even in the vicinity of and below the body-armature suspension resonance. This can allow considerable simplification of the test system instrumentation, in that force can be measured with an accelerometer system which is essentially identical to that used to measure the structural response.

In the pendulously suspended Free Body Mode, there is no additional external constraint on the body for static weight support. Hence, an axially oriented accelerometer on the body will produce an accurate force signal. However, when using the body acceleration method in conjunction with pendulous suspension of the body by means of vertically oriented support lines, it is necessary that the natural frequency of the "pendulum" formed by the support lines and shaker body be located several octaves below the lowest operating frequency.

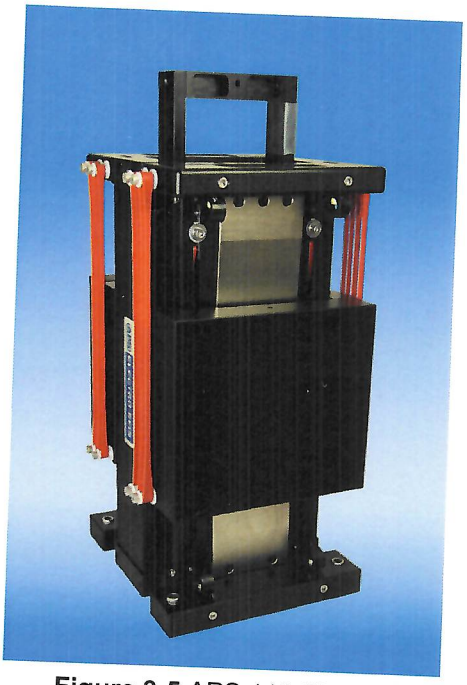


Figure 3-5 APS 113 Shaker equipped with APS 0112 Reaction Mass Assembly

FREE ARMATURE MODE

Many large test structures having horizontal surfaces such as floors require vertical force applied to these surfaces to excite resonant modes of vibration. The APS 113 Shaker may be used in a vertical Free Armature Mode by resting the rear end frame of the shaker on the horizontal surface of the test structure. In this mode, the armature provides reaction mass and allows the generated force to be applied through the shaker body to the horizontal surface on which the shaker is placed.

With the armature experiencing maximum acceleration, rated force is applied to test structure through the shaker body. Without additional mass attached to the armature, the armature stroke limits the generated force. Below this frequency, the stroke-limited force is proportional to the square of frequency.

The purpose of the APS 0112 - Reaction Mass Assembly is to lower the stroke-limited crossover frequency. Thereby gaining rated force output to a lower frequency and to lower the armature velocity minimizing the amplifier voltage requirement. Figure 3-5 shows the APS 0112 - Reaction Mass Assembly, including leveling feet and carrying handles attached to the APS 113 Shaker.



Figure 3-6 APS 113 Shaker equipped with APS 0052 - Auxiliary Table Assembly

NOTES

SHAKER TABLE MODE

Auxiliary table accessory units for both horizontal and vertical use employ the high load capability of the APS 113 armature guidance and suspension systems to provide long stroke tables for excitation of test loads. Figure 3-6 shows the APS 0052 - Auxiliary Table Assembly attached to the APS 113 Shaker.

Twenty-Five holes with helical inserts in the table provide for fixture or direct load mounting. In general, it is advisable to employ as many of the holes as possible when securing a load or fixture to the table, particularly if the load is expected to be resonant in the operating frequency range. Also, to equalize the loading on the shaker's guidance system, it is preferable to locate the center of gravity of a heavy load directly above the center mounting hole on the table.

The maximum mass load that may be placed on the table is limited by the allowable forces on the armature guidance bearing system and bearing shaft deflection. The recommended maximum static plus peak dynamic vertical load on the table is 22 kg (50 lbf).

The mechanical input impedance at the base of a test load that is resonant in the operating frequency range can vary by several orders of magnitude. At certain frequencies the impedance can be very much larger, while at others it can be very much smaller than the non-resonant values. Thus, the acceleration response of the table and test item base will exhibit the familiar "peaks" and "notches" as frequency is varied.

NOTES

ENVELOPES OF PERFORMANCE

The APS 113 Shaker's performance is most meaningfully stated in terms of the maximum force and velocity that can be obtained when driving a matched resonant (resistive) load. At very low frequencies, the maximum load or structure velocity at the drive point is limited by the 158-mm (6.25-in) maximum relative stroke between armature and body. The degree of limitation depends upon whether the shaker is being used in the Fixed Body Mode or in the Free Body Mode. Therefore, characteristic performance is best given in the form of graphs which present envelopes of the maximum force and velocity that can be delivered to a matched resonant structural input impedance as a function of frequency.

Figures 3-7 and 3-8 (See page 3-7) present the typical force and velocity envelopes for the Free Body Modes, i.e. pendulously suspended body, and cradle suspended body. In this mode the shaker body is allowed to move, and this reduces the absolute motion available to the armature and drive point such that relative motion lies within the maximum relative stroke.

STANDARD AND LOW IMPEDANCE COIL MODE

The drive coil of the APS 113 is wound in a manner which allow series or parallel connection, offering the user the choice of standard or low impedance. This option is required if the shaker is to be used with the APS 125 - Power Amplifier for extended frequency range or random noise excitation.
Refer to SECTION 5, SUPPORT DOCUMENTATION for Coil Connection.

NOTES

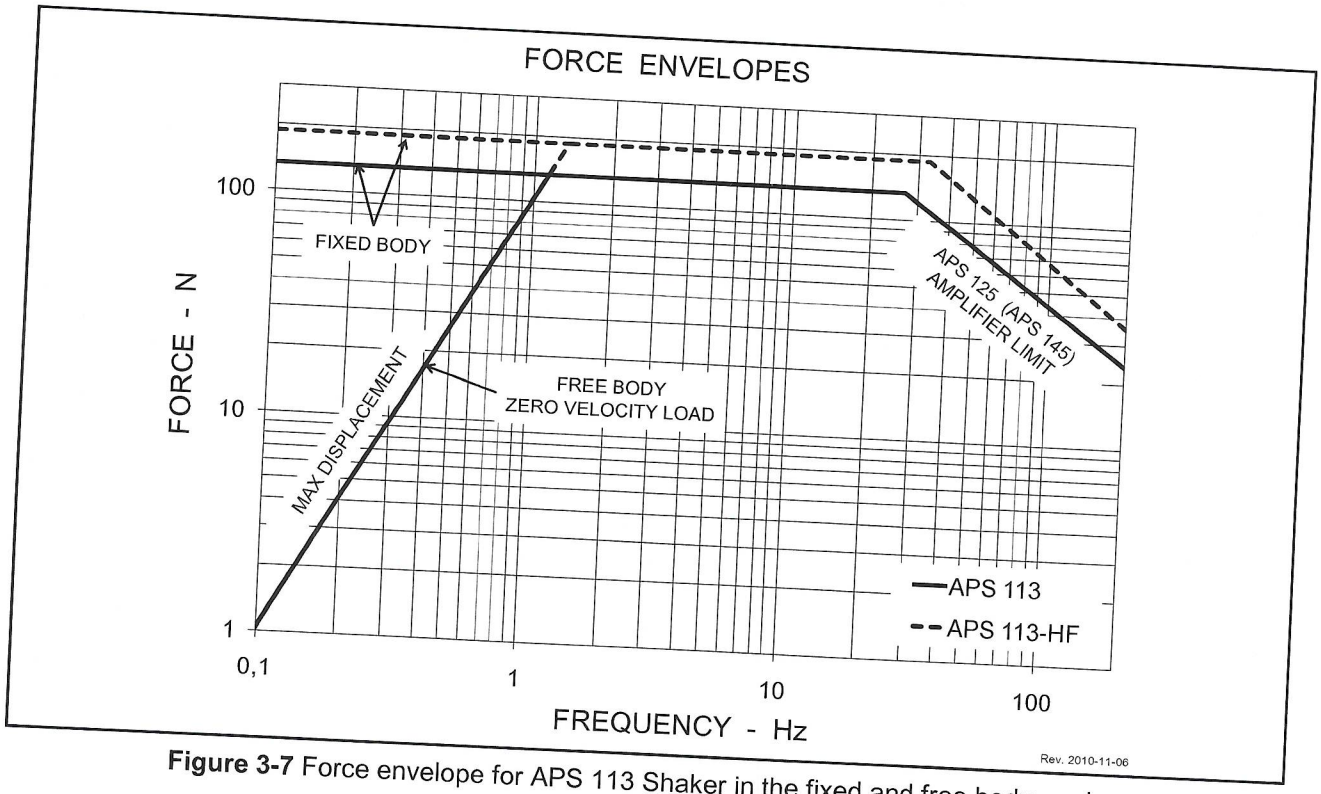


Figure 3-7 Force envelope for APS 113 Shaker in the fixed and free body modes

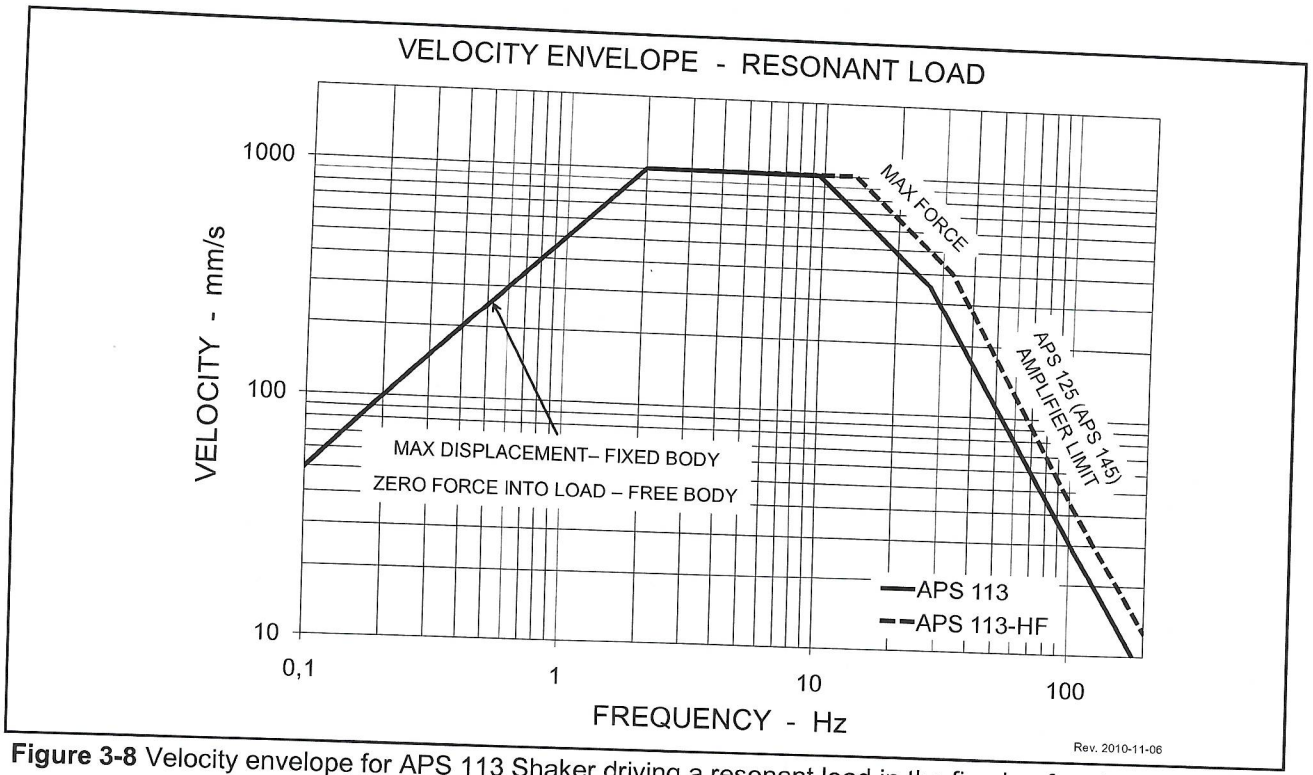


Figure 3-8 Velocity envelope for APS 113 Shaker driving a resonant load in the fixed or free body modes

4 Maintenance

REPLACEABLE PARTS

Section 5 contains a listing of all replaceable parts and subassemblies of the APS 113 Shaker. It provides a description of each part, its part number, and the total quantity used in the shaker.

Figure 4-1 is a photograph of a partially disassembled shaker which illustrates the replaceable parts listed in Section 5. Callout numbers in the figure correspond to item numbers in the list.

ORDERING INFORMATION

All replaceable parts may be obtained from APS Dynamics. When ordering replacement parts, give the full description and part number, the quantity desired, and the model and serial number of the shaker.

LISTS OF SERVICE TOOLS AND MATERIALS

In order to perform preventative maintenance and part replacement procedures, the following service tools and materials are recommended:

1. 3/16-inch hex key wrench (for 1/4-inch cap screws)
2. Torque wrench with 3/16 hex bit, long (for critical tightening of indicated cap screws).

INSPECTION AND PREVENTATIVE MAINTENANCE

The APS 113 Shaker does not require any periodic adjustments; however, certain inspection and preventative maintenance operations will insure trouble-free performance. Refer to the above paragraph for a list of service tools and materials.

Every 30 days or before any period of extended operation clean the bearing shafts with a lint-free wipe, removing any accumulated debris. Every 90 days or before any period of extended operation, check the magnet structure air gap for ferrous particles and clean if required. Follow the procedure for cleaning and parts replacement below.

NOTES

CLEANING AND PARTS REPLACEMENT PROCEDURES

In order to internally clean the APS 113 Shaker or to replace the Guidance Bearings or Bearing Shafts, proceed as follows:

DISASSEMBLY

1. Place the unit on a bench with the thrust axis in a vertical orientation with armature load attachment bridge upward.
2. Remove the four corner covers and armature suspension bands, allowing the armature to rest on the rear rubber stops.
3. For cleaning and installation of Bearing Housing Clamps, loosen the four 1/4-28 x 1-1/4 Cap Screws in the forward end frame about 6 mm (1/4 inch). With care to prevent the side covers and slide guides from falling, raise the forward end frame.
4. Lift off the side covers and suspension slide guides. Refer to Figure 4-1.
5. For cleaning and inspection of the armature, no other parts need be removed. Wipe all aluminum parts with a damp cloth to remove dirt. Wipe the bearing shafts with a lint-free wipe. Magnetic particles lodged in the magnet assembly air gap may be removed with masking tape.
6. To replace the Guidance Bearings or Bearing Shafts, remove the forward end frame screws (Step 3 above) and the end frame.

CAUTION

DO NOT ATTEMPT TO PLACE THE UNIT IN A HORIZONTAL POSITION FOLLOWING REMOVAL OF THE END FRAME. DAMAGE TO THE ARMATURE COIL MAY RESULT.

REASSEMBLY

1. Replace the forward end frame, engaging the forward magnet assembly shoulders and bearing shafts.
2. Replace the slide guides and side covers. *Be certain all pieces are in their proper location before replacing the End Frame Cap Screws.*
3. Install four 1/4-28 x 1-1/4 End Frame Cap Screws and gradually tighten to 14 Nm (130 in-lb).
4. Replace the suspension slides, suspension bands, and corner covers.

NOTES

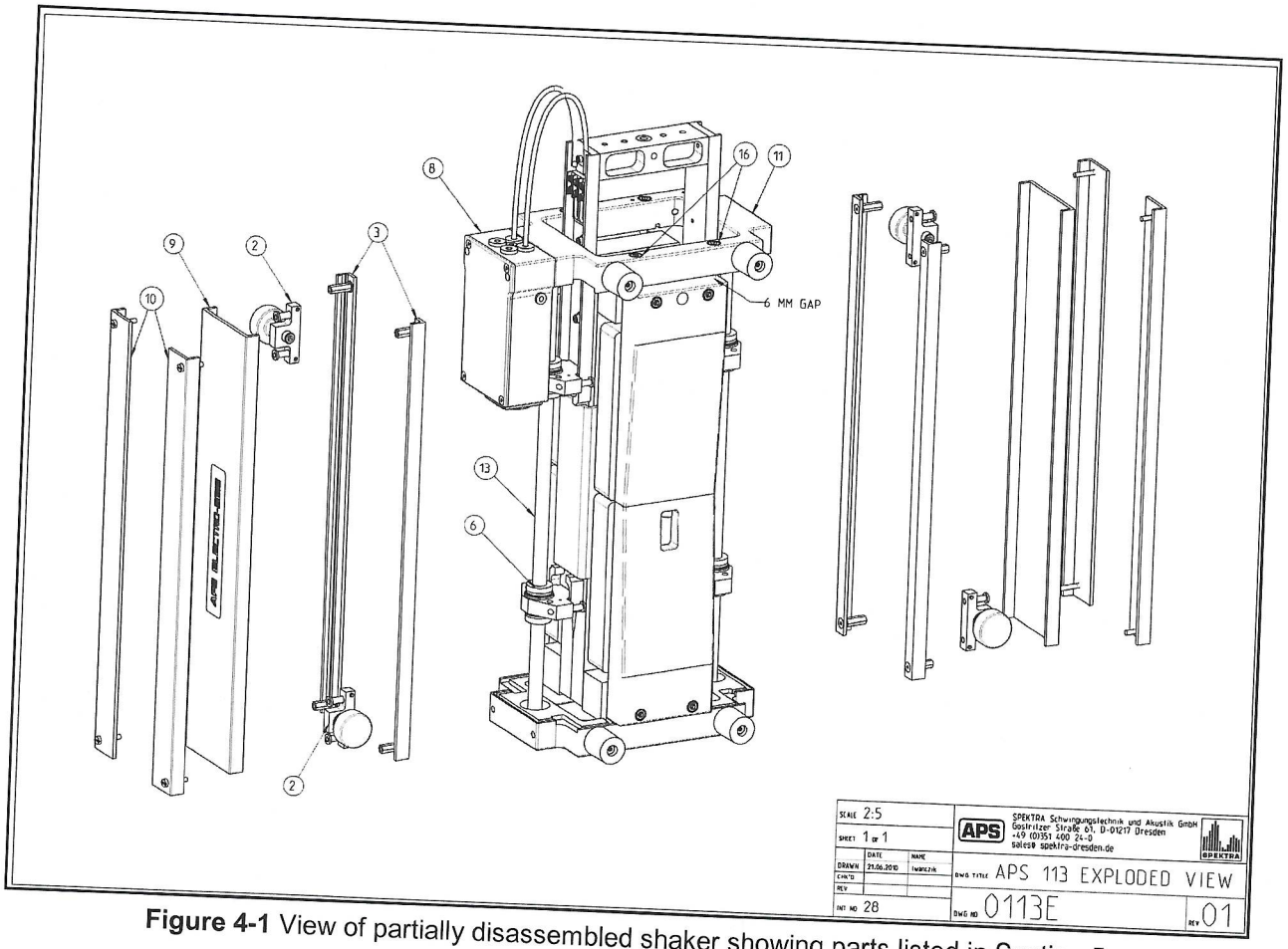


Figure 4-1 View of partially disassembled shaker showing parts listed in Section 5

5. Return the shaker to the horizontal position, resting on its feet, and check for free travel of the armature. The unit is now ready for operation.

NOTES

REPAIR/REPLACEMENT ACTION

If a problem occurs in the operation of the shaker or part repair/ replacement action becomes necessary, contact:

APS Dynamics, Inc. c/o
SPEKTRA Schwingungstechnik und Akustik GmbH Dresden
Heidelberger Str. 12
01189 Dresden, Germany

Phone: +49 351 40024 0
FAX: +49 351 40024 99
E-Mail: sales@spektra-dresden.com

Be prepared to give the serial number of the unit, the part numbers involved, and a complete description of the nature of the problem.

Refer to SECTION 5, SUPPORT DOCUMENTATION.

NOTES

5 Support Documentation

This section contains the following Support Documentation:

CALIBRATION INFORMATION 5-2

SHAKER TRANSFER FUNCTION 5-3

OUTLINE AND INSTALLATION DRAWING 0113M 5-4

APS 113/AMPLIFIER INTERCONNECT 0113C 5-5

REPLACEABLE PARTS LIST
(APS 113 ELECTRO-SEIS® SHAKER) 5-6

ACCESSORY INSTALLATION DRAWINGS
- 0052M
- 0077M
- 4451M / 4452M
- 0108M
- 0112M
- 0414M1 5-7

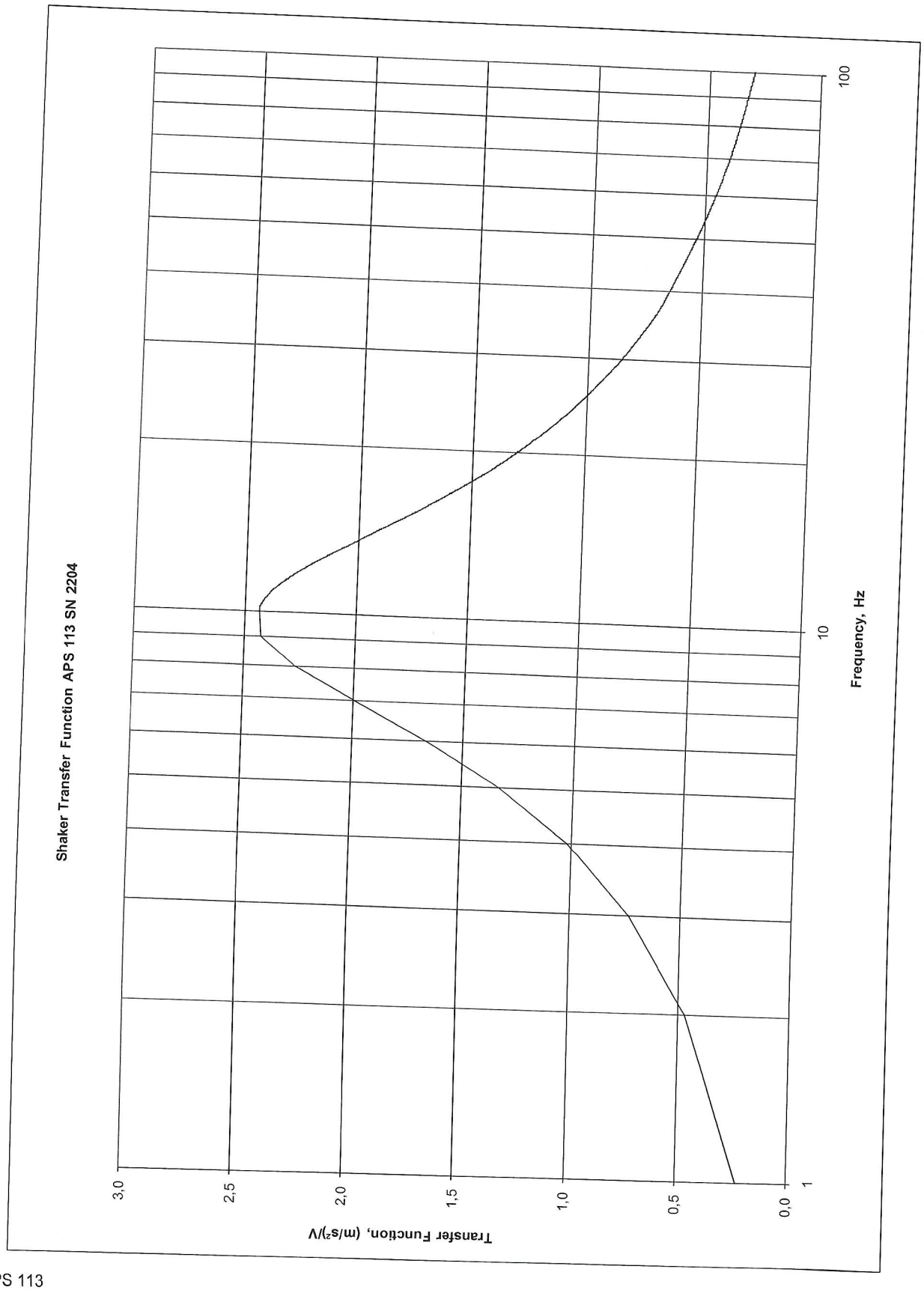
WARRANTY / REVISION INFORMATION

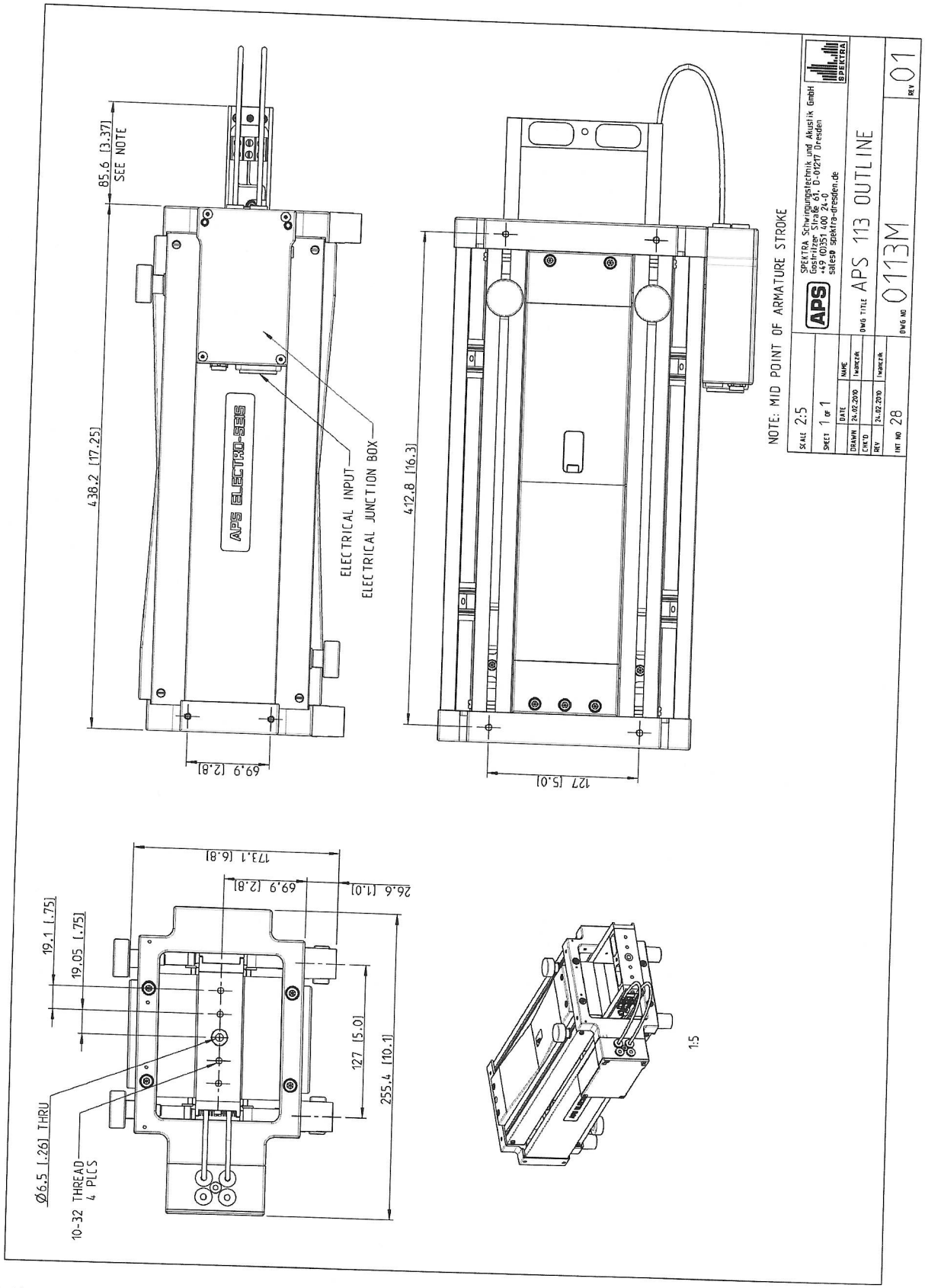
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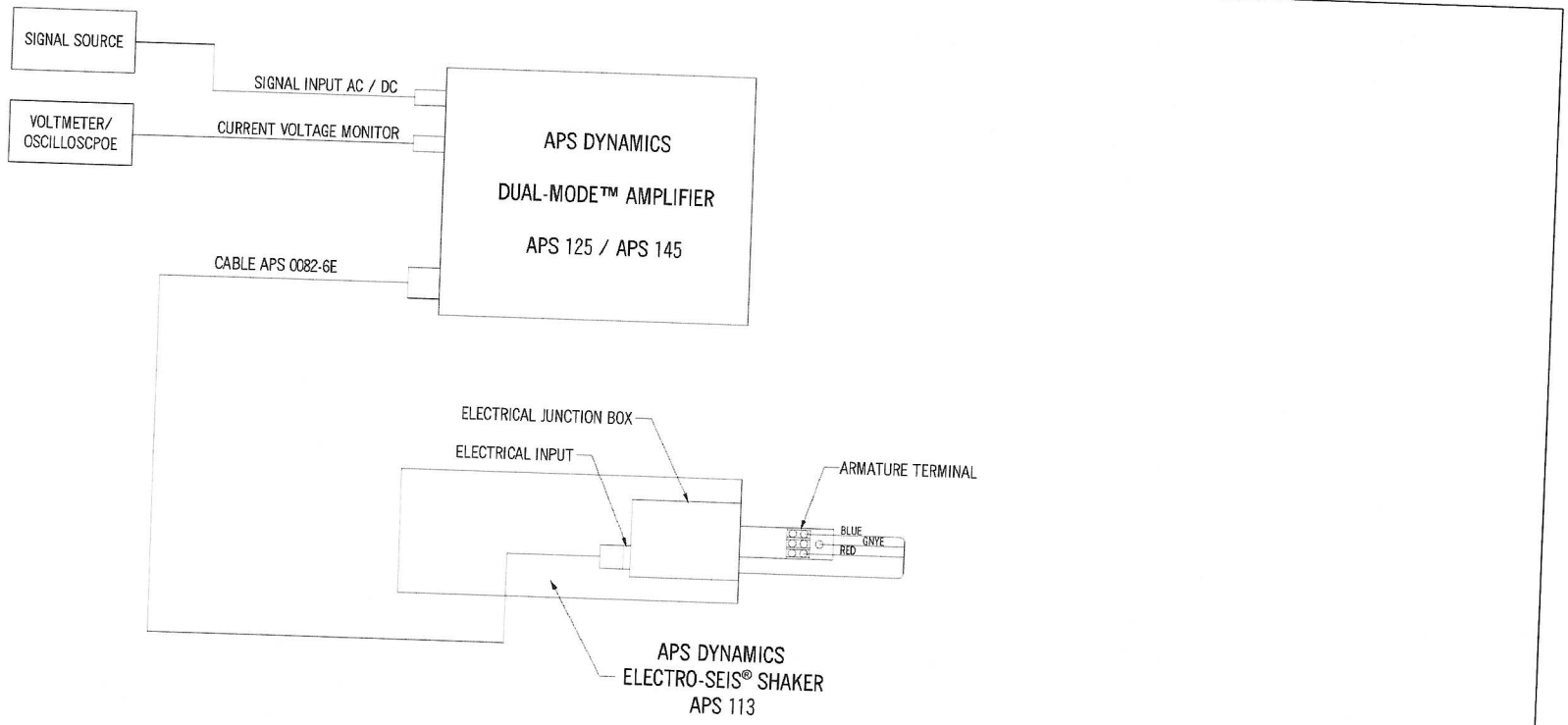
CALIBRATION INFORMATION

APS 113 ELECTRO-SEIS® SHAKER

Shaker Serial No:	2204	
Shaker Option:	STD	
Coil Option:	STD	
Accessories:	--	
Armature Weight:	4,87 lb	2,208 kg
Arm Weight With Bearing Housing Clamps:	4,87 lb	2,208 kg
Force Current Ratio:	6,01 lb/A	26,74 N/A
Current for 30 lb (133 N):	4,99 A peak	3,53 A rms

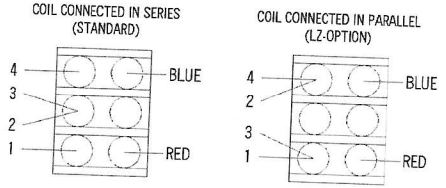

Shaker Transfer Function APS 113 SN 2204
Transfer Function, (m/s²)/V
3,0
2,5
2,0
1,5
1,0
0,5
0,0
Frequency, Hz
1
10
100


85.6 [3.37]
SEE NOTE
438.2 [17.25]
APS ELECTRO-SEIS
ELECTRICAL INPUT
ELECTRICAL JUNCTION BOX
69.9 [2.8]
412.8 [16.3]
127 [5.0]
NOTE: MID POINT OF ARMATURE STROKE
SCALE 2:5
SHEET 1 OF 1
APS
SPEKTRA Schwingungstechnik und Akustik GmbH
Gasanstalt Straße 61, D-01277 Dresden
+49 (0)351 400 24-0
sales@spektra-dresden.de
SPEKTRA
DWG TITLE APS 113 OUTLINE
DWG NO 0113M
REV 01
INT NO 28
DRAWN 24.02.2010 Iwanczak
CHK'D 24.02.2010 Iwanczak
REV
DATE
NAME
173.1 [6.8]
69.9 [2.8]
26.6 [1.0]
19.1 [.75]
19.05 [.75]
127 [5.0]
255.4 [10.1]
Ø6.5 [.26] THRU
10-32 THREAD
4 PLCS
1:5



SHAKER ELECTRICAL INPUT		
PIN	WITH APS AMPLIFIER	WITHOUT APS AMPLIFIER
1-	SHAKER – / GND	
1+	SHAKER +	
2-	CURRENT CONTROL Rx INPUT A	NOT CONNECTED
2+	EARTH (DO NOT CONNECT WITH GND!)	
3-	TEMP / AIR CONTROL	NOT CONNECTED
3+	OVERTRAVEL CONTROL	NOT CONNECTED
4-	CURRENT CONTROL Rx INPUT B	NOT CONNECTED
4+	+15 V / 150 mA → GND	NOT CONNECTED

COIL CONNECTION
ARMATURE TERMINAL



THE SHOWN COIL CONNECTION OPTIONS ARE ONLY VALID FOR THE APS 113.
DO NOT CHANGE THE COIL CONNECTION OF THE APS 113-HF!

NOTES:
1. BLUE AND RED LEADS MAY BE INTERCHANGED
2. LIMIT SIGNAL SOURCE OUTPUT TO 10 VOLTS-RMS OR LESS
3. VOLTMETER TO READ 0 TO 5 VOLT RMS MAXIMUM WITH SINEWAVE
4. OSCILLOSCOPE TO READ 0 TO 7 VOLT PEAK WITH RANDOM SIGNAL

SCALE		
SHEET 1 OF 1		
	DATE	NAME
DRAWN	17.06.2010	Iwanczik
CHK'D		
REV		
INT NO 28		

APS SPEKTRA Schwingungstechnik und Akustik GmbH
Gostritzer Straße 61, D-01217 Dresden
+49 (0)351 400 24-0
sales@ spektra-dresden.de

DWG TITLE APS 113 / AMPLIFIER INTERCONNECT

DWG NO 0113C REV 01

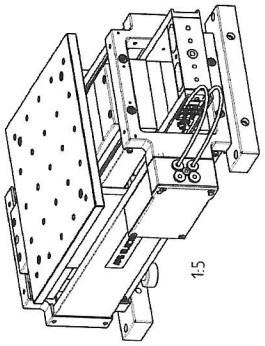
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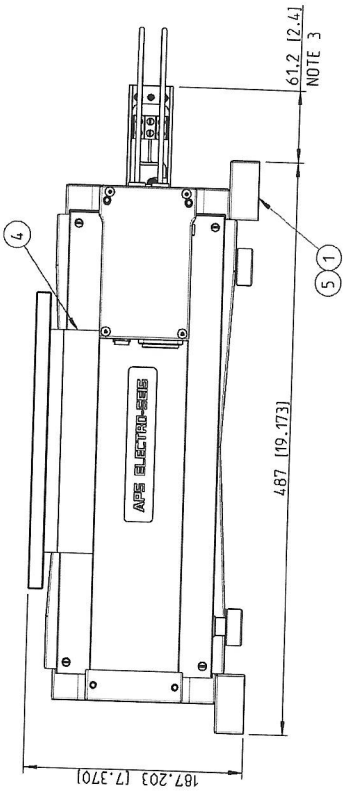
APS 113 ELECTRO-SEIS® SHAKER

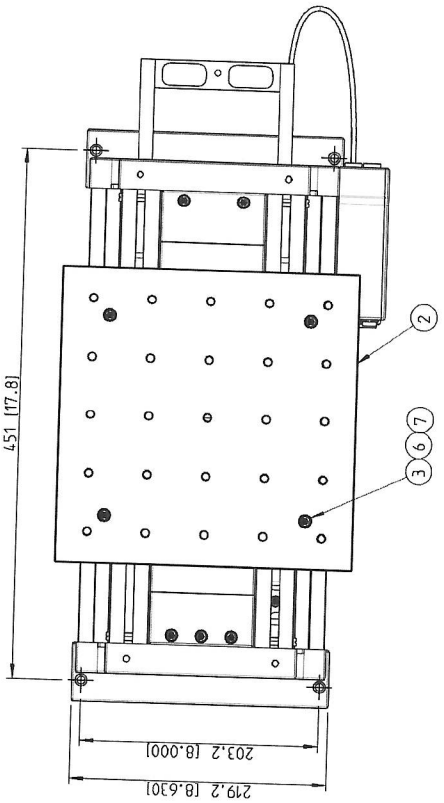
Item	Total Qty	Part Description	APS Part No.
1.	1	Armature Assembly	
2.	4	Suspension Slide Assembly	2801
3.	4	Slide Guide Assembly	2802
4.	4	Rubber Foot Assembly	2803
5.	2	Pole Piece Assembly (2 pairs)	2804
6.	4	Linear Ball Bushing Assembly	2805
7.	4	Bearing Housing Assembly	2806
8.	1	Electrical Junction Box Assembly	2807
9.	2	Side Cover	3306
10.	4	Corner Cover	28080001
11.	1	Forward End Frame	28080002
12.	1	Rear End Frame	28080003
13.	2	Bearing Shaft, Stainless Steel	28080004
14.	4	Suspension Band (heavy)	28080005
15.	4	Suspension Band (light)	28080007
16.	8	Cap Screw, Socket Head, 1/4-28 x 1-1/4	28080008
17.	4	Brass Bushing	28080016
18.	1	Wooden Shipping Box	28080021
			28080022

REF	DESCRIPTION	PART NO	QTY
1	FEET EXTENSION BAR	4450	2
2A	LOAD MOUNTING TABLE	4451	1
2B	LOAD MOUNTING TABLE	4452	1
3	BEARING HOUSING CLAMP	4453	4
4	TABLE SPACER	44010001	2
5	SOC HD SCREW 1/4-20 X 1.5	44010004	4
6	BTN HD SCREW 10-24 X 0.75	44010006	8
7	SOC HD SCREW 1/4-20 X 2.5	44010008	4
-	WOODEN CASE 435 X 325 X 150 MM	44010003	1
-	HEX KEY 3/16	44010005	1
-	TORX KEY NO. 25	44010007	1

NOTES:
1. ITEM 2A IMPERIAL OPTION (REFER TO DWG 4451M FOR HOLE PATTERN)
   ITEM 2B METRIC OPTION (REFER TO DWG 4452M FOR HOLE PATTERN)
2. ITEMS 3 AND 6 FACTORY INSTALLED WHEN ORDERED WITH SHAKER
3. MID POINT OF ARMATURE STROKE







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Gasanstaltstraße 6f, D-01237 Dresden
+49 (0)351 400 2410
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SCALE	3:10	
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	DATE	NAME
DRAWN	01.03.2010	HOMEWIN
CHK'D		
REV		
INT NO	4401	

DWG TITLE: 0052 INSTALLATION
DWG NO: 0052M
REV: 01

REF	DESCRIPTION	PART NO	QTY
1	FEET EXTENSION BAR	4450	2
2A	LOAD MOUNTING PLATE	4451	1
2B	LOAD MOUNTING PLATE	4452	1
3	BEARING HOUSING CLAMP	4453	4
4	TABLE SUPPORT TUBE (R)	4455	2
5	TABLE SUPPORT TUBE (L)	4456	2
6	SUSPENSION SUPPORT BAR	4457	2
7	SUSPENSION SUPPORT BRACKET	4458	4
8A	SUSPENSION BAND HEAVY	28080007	4
8B	SUSPENSION BAND EXTRA HEAVY	44030001	4
9	SOC HD SCREW 1/4-20 X 1	35020012	4
10	SOC HD SCREW 1/4-20 X 0.75	35020013	4
11	SOC HD SCREW 1/4-20 X 2.75	35020016	4
12	BTN HD SCREW 10-24 X 0.75	44010006	8
13	SOC HD SCREW 1/4-20 X 2.5	44010008	8
-	HEX KEY 3/16	44010005	1
-	TORX KEY NO. 25	44010007	1
-	WOODEN CASE 525 X 405 X 150 MM	44110001	1

NOTES: 1. ITEM 2A IMPERIAL OPTION (REFER TO DWG 4451M FOR HOLE PATTERN)
ITEM 2B METRIC OPTION (REFER TO DWG 4452M FOR HOLE PATTERN)
2. ITEMS 3 AND 12 FACTORY INSTALLED WHEN ORDERED WITH SHAKER
3. ITMES 8A AND 8B AS REQUIRED
4. MID POINT OF ARMATURE STROKE

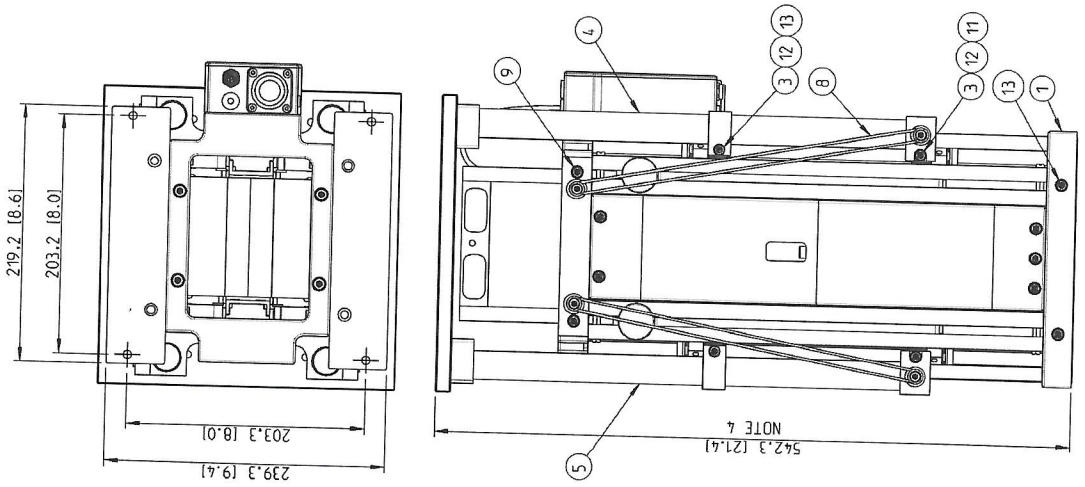
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sales@ spektra-dresden.de

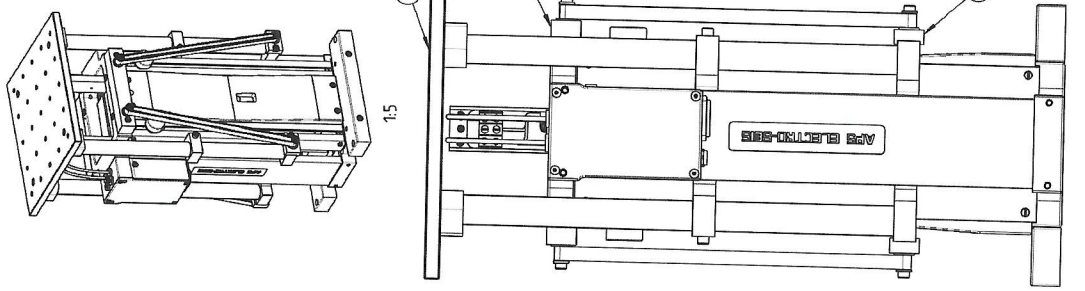
APS ELECTRO-SEIS

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	DATE	NAME
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CHK'D		
REV		

DWG TITLE 0077 INSTALLATION





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