Brüel & Kjær

type 4810

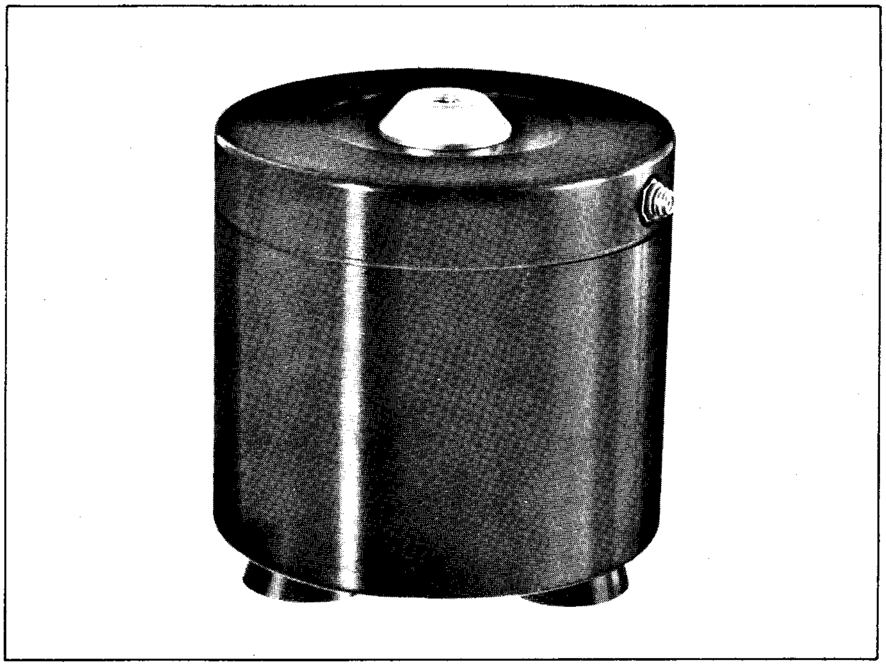
Mini-Shaker

FEATURES:

- Force rating 10 Newton (2,25 lbf) Sine Peak
- Frequency range DC to 18 kHz
- First axial resonance above 18 kHz
- Max. bare table acceleration 550 ms^{-2} (56 g)
- Rugged construction

USES:

- Calibration of accelerometers
- Vibration testing of small objects
- Educational demonstrations
- Mechanical impedance measurements



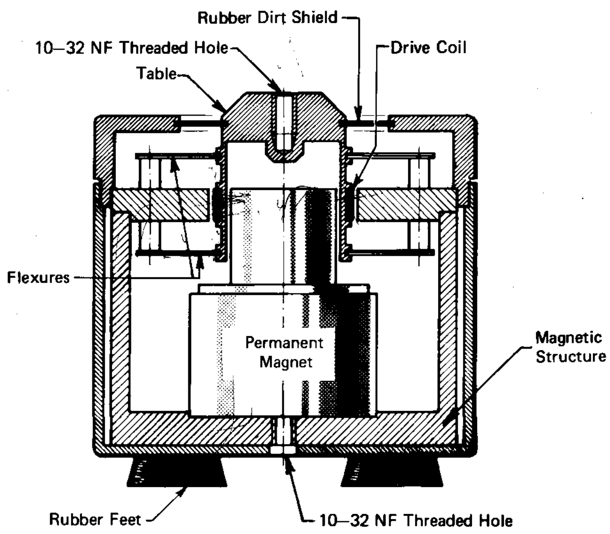


Fig. 1. Sectional drawing of the Mini-Shaker Type 4810

The Mini-Shaker Type 4810 is a small machine for the dynamic excitation of lighter objects, it is manufactured from quality materials to a high degree of precision and has proved to be a reliable and versatile tool in dynamic testing.

Type 4810 is well suited as the motive force generator in mechanical impedance measurements where only smaller forces are required.
It can also be used in the calibration of vibration transducers, both to determine their sensitivity by comparison with a standard accelerometer, and to determine their frequency response up to 18 kHz.

The Mini-Shaker is of the electrodynamic type with a permanent field magnet. A coil, which is an integral part of the table structure, is flexibly suspended in one plane in the field of the permanent magnet. An alternating current signal, provided by an external oscillator is passed through the coil to produce a vibratory motion at the table. A sectional drawing illustrating the method of construction is shown in Fig. 1.

The suspension system consists of radial flexure springs which restrict the moving element to almost perfectly rectilinear motion. Laminated flexure springs provide a high degree of damping to minimize distortion due to flexure resonances. The frequency response curves shown in Fig. 2 show the highly damped flexure resonance around 50 to 60 Hz.

The object to be vibrated is attached to the table by means of a 10 — 32 NF screw; the thread size commonly used for mounting accelerometers. Performance limits which are defined by the maximum displacement (6 mm), maximum force (10 N or 7 N depending on frequency), and the first axial resonance of the moving element (above 18 kHz), are graphically shown in Fig. 3.

Within these limits, the attainable acceleration can be determined by the expression.

$$a = \frac{F}{W}$$

where a = acceleration in ms^{-2} ($1\ ms^{-2} = 0{,}102\ g$)
F = shaker rated force in Newtons
W = exciter moving element weight + test object weight in kg

Examples of maximum test object weight for accelerations of 20 g and 5 g are drawn in on the curve.

In order to attain full rated output force from the 4810 it should be driven by Power Amplifier Type 2706. This is a power amplifier specially designed to drive small vibration exciters and has a current limiter to prevent overdriving the 4810. The Mini-Shaker can also be driven at a lower level by Sine Generator Type 1023. This has an output of 7,0 W which will drive the Mini-Shaker to a rated force of approximately 3,9 N (0,9 lbf) peak.

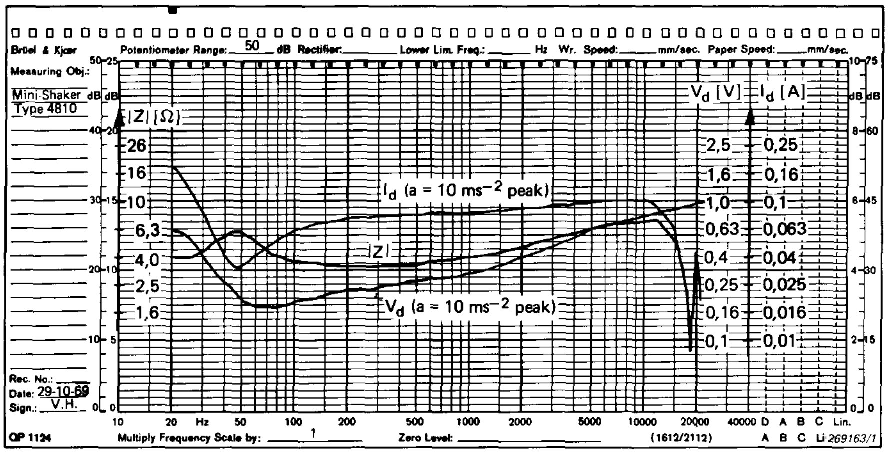


Fig. 2. Frequency response of the 4810 for Impedance (Z), current (I) and voltage (V)

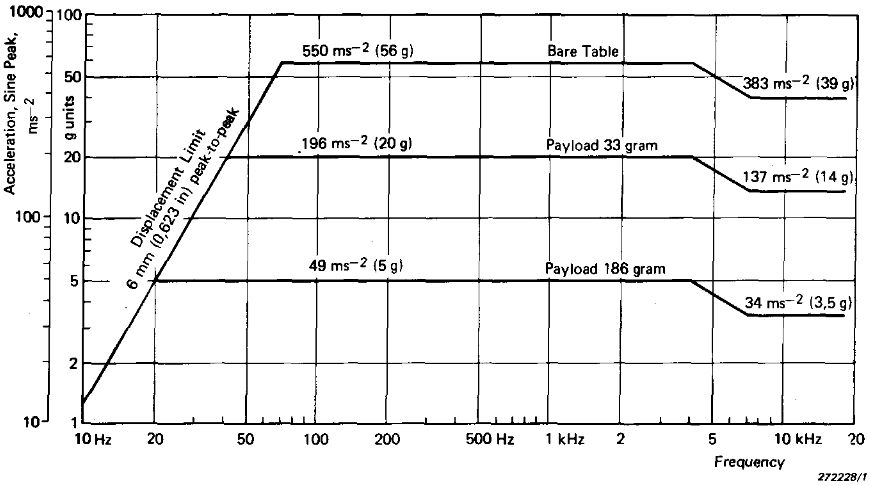


Fig. 3. Sine performance curves for the 4810

Specifications 4810

Frequency Range:
DC to 18 kHz

First Major Armature Resonance:
Above 18 kHz

Force Rating (Peak):
10 Newton (2,25 lbf). 65 Hz to 4 kHz
7 Newton (1,5 lbf). 65 Hz to 18 kHz

Max. Bare Table Acceleration (Peak):
550 ms^{-2} (65 Hz to 4 kHz)
383 ms^{-2} (4 kHz to 18 kHz)
($1\ ms^{-2} = 0{,}102\ g$)

Max. Displacement (Peak-to-Peak):
6 mm (0,236 in)

Dynamic Flexure Stiffness:
2 Newton/mm (11,5 lbs/in)

Dynamic Weight of the Moving System.
18 grams

Magnetic Field:
Permanent magnet

Max. Input Current:
1,8 A. RMS

Coil Impedance:
3,5 Ω at 500 Hz

Connection:
Microsocket NF 10 — 32

Table Size:
14 mm (0,55 in) diameter

Fastening Thread:
NF 10 — 32

Weight:
1,1 kg (2,4 lb)

Dimensions:
Diameter: 76 mm (3 in)
Height: 75 mm (2,9 in)

Accessories Available:
Cable for connection of Mini-Shaker to Power Amplifier AO 0069

Mounting Accessories (includes isolated studs YP 0150 and non-isolated studs YQ 2960) UA 0125

2. OPERATION

2.1. MOUNTING THE 4810

For accelerometer calibration and testing of small test objects the 4810 can be used in an upright position, standing on its three rubber feet. If a more secure mounting arrangement is required, it may be fastened to a workbench via the 10 - 32 NF threaded hole at the centre of its base or the 3 mm screws fastening its three rubber feet may be used.

2.2. MOUNTING TEST OBJECTS

The vibration table of the 4810 is provided with a single fixing hole. This has a 10 - 32 NF reinforced helical steel thread and is 10 ± 0,1 mm (0,4 ± 0,004 in) deep. For fixing accelerometers and vibration test objects to the table the 10 - 32 NF steel mounting studs YQ 2960 and isolated mounting studs YP 0150 are available. The correct mounting torque is 1,76 Nm (15 lb in).

To prevent damage to the 4810 always use a torque wrench for fixing accelerometers and test objects onto the table and ensure that the mounting stud does not bottom in the fixing hole. Also ensure that the test object is mounted with its centre of gravity in line with the centre of the vibration table, as otherwise unbalanced loads may cause the table drive coil to rub against the pole piece of the 4810.

When a test object is mounted directly on the vibration table it will excert a force on the table creating a static displacement. If this is found to be too large the test object may be suspended in resilient straps, so that its full mass does not bear directly on the table.

2.3. CONNECTION OF POWER AMPLIFIER

The range of B & K Exciter Control Generators and Power Amplifiers which may be used with the 4810 are shown in Fig.2.1.

The 4810 can be powered directly from the LOAD OUTPUT socket of Sine Generator Type 1023. The maximum output is 7 W which will drive the 4810 to a rated force of approximately 3,9 N (0,9 lbf) peak. For full rated otput force of 10 N (2,25 lbf) a Power Amplifier Type 2706 should be included in the set-up. This is specially designed to drive small vibration exciters and has a current limiter to prevent overdriving the 4810 (CAUTION: The current limiter on the 2706 has 2 settings and care must be taken to choose the 1,8 A setting. The Mini-Shaker may otherwise be overdriven and ultimately damaged).

Connection of the POWER INPUT socket of the 4810 to the 1023 Sine Generator or the 2706 Power Amplifier can be made using a B & K cable AO 0069 with a Miniature Coaxial Plug in one end and a twin banana plug in the other.

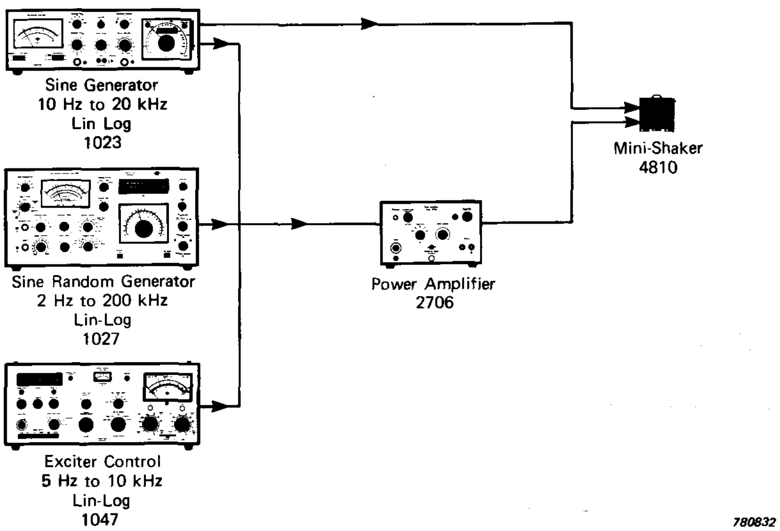


Fig. 2.1. B & K Exciter Control Generators and Power Amplifiers for use with the 4810 Mini-Shaker

3. OPERATING CHARACTERISTICS

3.1. CONSTRUCTION

A sectional view of the 4810 Mini-Shaker is shown in Fig.3.1.

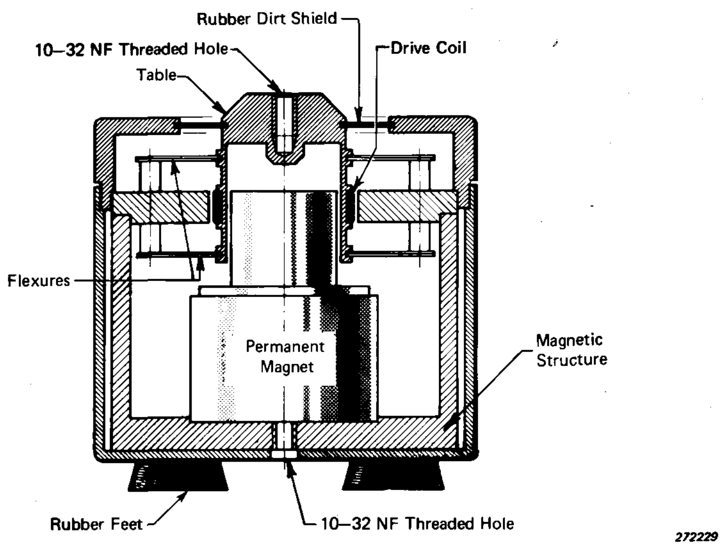


Fig.3.1. Mini-Shaker Type 4810

3.1.1. Magnetic Assembly

The 4810 has a columax alloy permanent magnet. This is epoxy bonded to the base of a cast iron structure, at the top of which is mounted a cast iron flange. From the magnet a high purity, cylindrical, iron pole piece projects up into the centre of the flange creating a circular air gap in which a magnetic field of approximately 1 Tesla (10^4 Gauss) is produced. The field strength above the table top is insignificant and therefore will not normally harm sensitive equipment used near the Shaker.

3.1.2. Moving Element

The moving element is a thin hollow cylinder with a vibration table at one end and a drive coil at the other. It is designed to provide the best possible coupling between the force generated by the drive coil and the test object on the vibration table. For maximum bare table acceleration and a high resonance frequency it is machined from a light weight aluminium solid. The vibration table has been hardened by an electrochemical process.

The drive coil is wound on the core element in such a way that it is always in the magnetic field. It has a nominal impedance of 3,5 Ω at 500 Hz. The maximum drive current rating is 1,8 A RMS.

The moving element is supported in the field gap of the magnet assembly by radial flexure springs which restrict the moving element to almost rectilinear motion, allowing less than 3% transverse acceleration up to 5 kHz. The flexure springs are made of two layers of spring steel plate separated by rubber. This construction provides a high degree of damping which helps minimize distortion due to flexure resonances.

The maximum displacement limit of the moving element is 6 mm (0,234 in) peak to peak. If the Mini-Shaker is overdriven an audible bumping sound will be heard, warning that the drive level should be reduced immediately.

3.2. FREQUENCY RESPONSE AND RESONANCE

In Fig.3.2 is shown a plot of the frequency response of the 4810 Mini-Shaker. The current I_d, voltage V_d and the impedance $|Z|$ in A, V and Ω respectively is plotted with respect to frequency for a constant acceleration of 10 ms $^{-2}$.

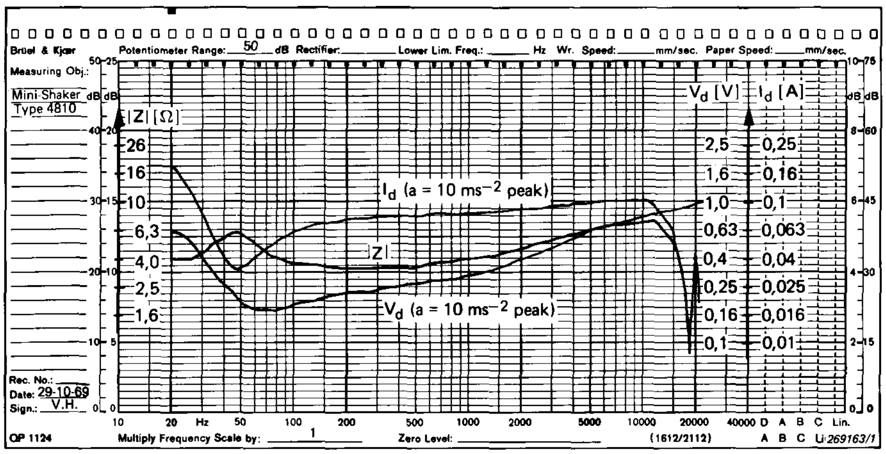


Fig.3.2. Typical frequency response of the 4810 Mini-Shaker

The frequency response shows a peak in the impedance and a drop in current at about 50 Hz indicating a resonance point. This is the suspension resonance, occuring between the element and its fastening. There is a second peak at about 18 kHz, which is the first major axial resonance peak of the moving element itself.

3.3. FORCE RATING AND OTHER OPERATION LIMITS

The force required to vibrate mass "m" with an acceleration "a" is given by:

$$F = ma$$

By rearranging and including the effective mass "m_e" of the Mini-Shaker's moving element, we obtain:

$$a = \frac{F}{m + m_e}$$

from which the maximum acceleration of the Mini-Shaker with any payload may be calculated.

Example

The 4810 Mini-Shaker has a moving element with effective mass m_e = 0,018 kg and a maximum force rating of 10 Newton. The maximum acceleration produced when loaded by a test object of mass 0,1 kilogram is given by:

$$a = \frac{F}{m + m_e}$$

$$a = \frac{10}{0,1 + 0,018}$$

$$a = 84,7\ \text{ms}^{-2} \text{ equivalent to } 8,6\ \text{g}$$

The maximum acceleration with other loads can be calculated in the same way or determined from the load rating curves given in Fig.3.3.

At frequencies above 70 Hz the limits are based solely on the amount of force available. However, for a given acceleration level, displacement increases as frequency decreases. Therefore at frequencies up to 70 Hz the Mini-Shaker must be held to its 6 mm (0,236 in) maximum displacement limit, to avoid damage.

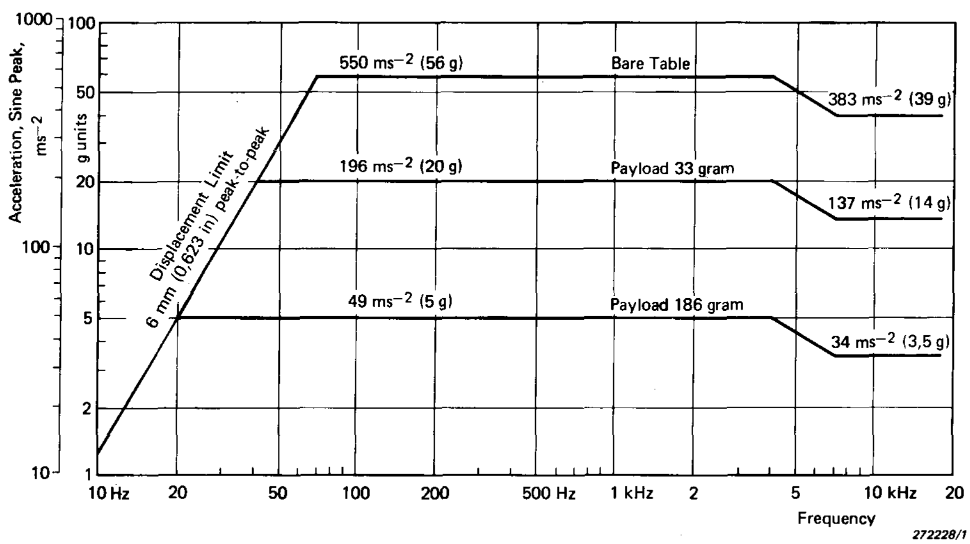


Fig.3.3. Performance limits for sine operation of the 4810 Mini-Shaker