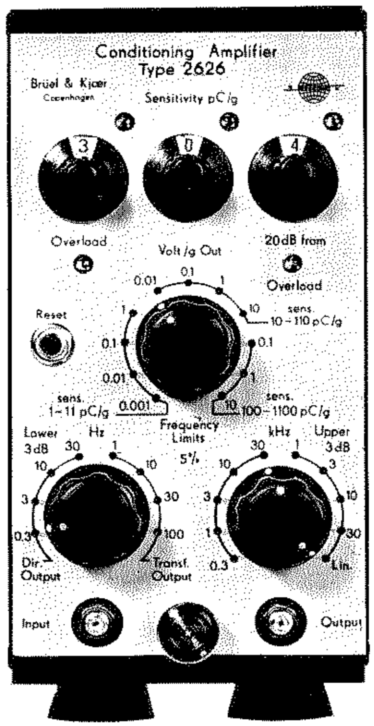
Instructions and Applications



Conditioning Amplifier Type 2626

This charge amplifier contains a three digit sensitivity adjustment network offering wide conditioning possibilities to different transducers (1–1100 pC/g). Output of the amplifier can be adjusted stepwise between 1 mV/g and 10 V/g depending on the transducer's sensitivity and is available either directly or through an output transformer. The lower and upper limiting frequencies can be adjusted stepwise.

CONTENTS

1. INTRODUCTION

1.1. GENERAL

When measuring vibration by means of an accelerometer, it is necessary to incorporate a preamplifier between it and the measuring amplifier. The preamplifier is introduced in the measuring circuit for two reasons:

1. to transform the high output impedance of the accelerometer to a lower value and

2. to amplify the relatively weak output signal from the accelerometer.

The signal from the piezoelectric accelerometer appears as a voltage across a capacitive impedance. As the capacitive output impedance of the accelerometer is very high, the associated amplifier must be of a special design having a high input impedance. This is necessary in order to avoid loading of the accelerometer and thereby obtaining decreased sensitivity and limitation at the low end of the frequency range.

The combination of a charge amplifier and a piezoelectric accelerometer gives a sensitivity which is independent of cable length within very wide limits. This feature makes a charge amplifier especially attractive in vibration systems where different cables are used. The Conditioning Amplifier Type 2626 may be used with cable lengths up to several thousand meters.

Another advantage the 2626 Amplifier offers is the wide conditioning possibilities to different transducers and measuring requirements. It features a 3 digit sensitivity adjustment network which enables the amplifier sensitivity to be adjusted to the particular transducer used. The network is calibrated in pC/g. Output of the amplifier can be adjusted stepwise between 1 mV/g and 10 V/g, depending on the transducer sensitivity. A maximum sensitivity of 1 V/pC is available. The output signal is available either directly coupled or through a transformer (switchable) for floating output.

Stepwise adjustable HP and LP filters are incorporated, by which the frequency limits can be adjusted independent of sensitivity. The filter scales give the 5% as well as 3 dB frequency limits. The lowest frequency limit for the amplifier is 0.3 Hz which makes it quite suitable for measurement of impulses.

Two neon indicators are connected to the output, one for overload and the other for underload which lights when the signal level is at least 1 V peak. On account of quick recovery time after overload, the amplifier is also suitable for use in a servo-loop in exciter systems.

1.2. CHARGE AMPLIFIER

The Conditioning Amplifier Type 2626 has been designed for use with accelerometers, where it is required that the measuring system be independent of the cable length connecting the accelerometer to the preamplifier.

The active elements of a piezoelectric accelerometer are small discs of polarized ceramic which when deformed mechanically, develop a charge across opposite faces of the discs. The equivalent circuit of this system can be represented either as a capacitance C_t across which a charge $S_q\,\alpha$ appears (Fig.1.1a), or as a capacitance C_t in series with a voltage generator $S_v\,\alpha$ (Fig.1.1b) where

S_q = charge sensitivity (pC/g)
S_v = voltage sensitivity (mV/g)
α = acceleration (g)

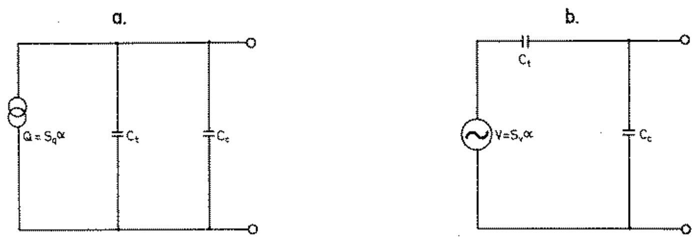


Fig.1.1. a) Charge equivalent circuit b) Voltage equivalent circuit

From the voltage equivalent circuit it can be seen that the cable capacitance C_c and C_t act as a voltage divider, reducing the signal appearing at the other end of the cable. The cable capacitance is proportional to its length, which means that for very long cables, the voltage signal appearing at

the end, which is fed into the preamplifier is very small. Also, each time the cable length is changed, a new voltage sensitivity factor must be calculated, since the voltage divider has new component values.

If, however, an amplifier which gives an output voltage proportional to input charge is used, it can be seen from Fig.1.1a) that the cable capacitance would have no effect on the sensitivity.

This, then, is the difference between a charge amplifier and a voltage amplifier. A voltage amplifier is sensitive to variations in input voltage and so is sensitive to cable capacitance. A charge amplifier is sensitive to variations in input charge, and since the capacitance across which the charge appears does not alter the charge, the charge amplifier output is independent of the cable capacitance.

1.3. PRINCIPLE OF THE CHARGE AMPLIFIER

Basically, a charge amplifier consists of a high gain operational amplifier with a feedback capacitor, C_f, as in the equivalent circuit of Fig.1.2. It can be shown that the voltage output of this circuit is given by

$$V_o = \frac{QA}{C_t + C_c + C_f\,(1 - A)}$$

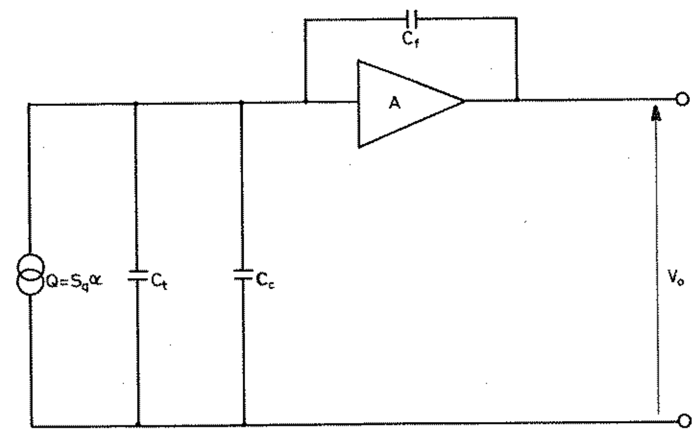


Fig.1.2. Equivalent circuit of charge amplifier

Since A (the open loop gain of the amplifier), is very large, then usually

$$|C_t + C_c| \ll -|C_f\,(1 - A)|$$

so the output becomes

$$V_o = \frac{-Q}{C_f}$$

Hence if C_f remains constant, the output voltage is directly proportional to the charge appearing across the accelerometer and the cable capacitance C_c normally has a negligible effect. Only when C_c becomes comparable to AC_f will it affect the gain.

2. CONTROLS

2.1. FRONT PANEL

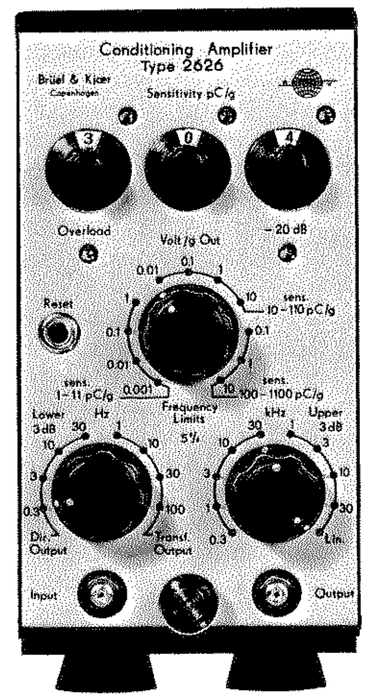


Fig.2.1. View of front panel

The front panel of the preamplifier is as shown in Fig.2.1, and the functioning of the various control knobs is as follows:

VOLT/g OUT: Depending on the accelerometer sensivity, the output sensitivity may be selected between 1 mV/g – 10 V/g, as shown in the ranges below.

Maximum sensitivity of 1 V/pC is available. Minimum sensitivity of 0.1 mV/pC is available.

Acc. Sensitivity	Output Sensitivity
1– 11 pC/g	0.001–0.01–0.1–1.0 V/g
10– 110 pC/g	0.01–0.1–1.0–10.0 V/g
100–1100 pC/g	0.1–1.0–10.0 V/g

A neon lamp will be lit indicating the decimal point for the accelerometer sensitivity, depending on the range chosen.

SENSITIVITY pC/g:

The three knobs permit conditioning of accelerometer charge sensitivity within the range 1.00–1099 pC/g. The decimal point is indicated by one of the three neon lamps placed above the sensitivity knobs.

For impulse measurements the signal can be attenuated (if required) by selecting higher accelerometer sensitivity positions than the actual sensitivity of the accelerometer used.

FREQUENCY LIMIT:
Lower

On both DIRECT and TRANSFORMER outputs, the choice of lower limiting frequencies (3 dB down) are 0.3, 3, 10, and 30 Hz. These figures correspond to lower limiting frequencies 5% down at 1, 10, 30, and 100 Hz. The cut-off slope is 6 dB/octave.

FREQUENCY LIMIT:
Upper

The upper limiting frequencies (3 dB down) can be selected as 1, 3, 10, 30 kHz and linear, corresponding to 0.3 1, 3, 10, and 30 kHz maximum 5% down. Cut-off slope 12 dB/octave.

RESET:

The reset button restores the preamplifier to normal working conditions after overload. This is especially useful when the preamplifier is used for low frequency shock measurements.
It should be noted that for normal impulse overload, the recovery time is negligible.

OVERLOAD:

The neon indicator lights up when the signal is greater than 10 Volt peak.

–20 dB:

The neon indicator lights up only when the signal is above 1 V peak.

INPUT:

Miniature coaxial socket for connection of accelerometer cable. Plug type JP 0012.

OUTPUT:

Miniature coaxial socket for connection of cable to analyzing equipment.
Although in the direct output mode the connection is not DC blocked, the DC offset is negligible. Typical 1–2 mV. Max. ±10 mV.
In the transformer output mode, the output is floating.

2.2. REAR PANEL

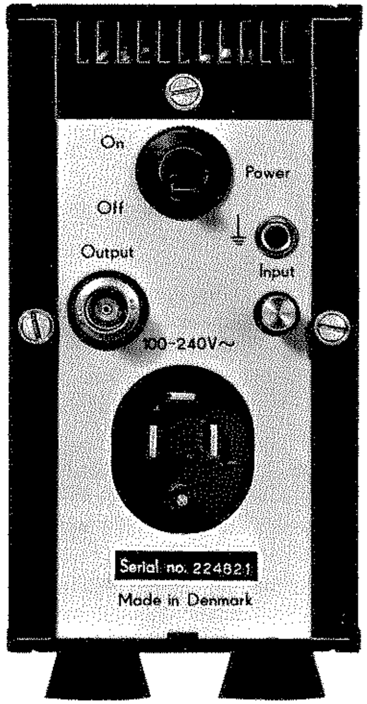


Fig.2.2. View of rear panel

Fig.2.2 illustrates the sockets on the rear panel.

POWER:	This switch connects power to the instrument. Any line voltage between 90 and 265 Volts AC can be used without adjustment. Maximum consumption is approx. 7 Watts.
INPUT:	An alternative input connected in parallel with the input socket on the front panel, plug JP 0012.
OUTPUT:	BNC output socket, connected in parallel to front panel output. For many purposes it could be more convenient to use than the miniature coaxial output.

3. OPERATION

The main purpose of the 2626 Conditioning Amplifier is to convert a high impedance signal from an accelerometer to a low impedance signal scaled to suitable sensitivity for use with subsequent instrumentation. Exact information about the vibration at the point of measurement can then be obtained provided the following conditions are fulfilled:

1. The accelerometer sensitivity must be known over the applicable frequency range. Such information is generally supplied, otherwise the accelerometer must be calibrated.

2. The accelerometer must be fixed to the vibrating specimen in such a way that the frequency response curve is not altered. This is particularly important where frequencies higher than about 2000 Hz are concerned.

3. The mass of the accelerometer must not significantly affect the vibration at the measuring point.

4. The conditioning attenuators of the Preamplifier must be set to the correct accelerometer sensitivity. The output sensitivity should be chosen to be as high as possible (without overloading), to get best S/N performance.

3.1. INPUT

The input is single-ended with microplug connections in parallel at the front and rear of the instrument. Whenever the front panel input is used, the rear input should be protected by the small extension nut, and vice versa, in order to eliminate hum pick-up.

For low frequency measurements it is important to keep the cable connections clean, both at the accelerometer and at the preamplifier end, in order to preserve the high input impedance of the amplifier.

Mininoise coaxial accelerometer cable is available in any length up to 200 m (600 ft) from Brüel & Kjær. There are two types, Type AC 0010 (PVC insulated) for ordinary temperatures, and Type AC 0005 (Teflon) for a wide temperature range (−90 to + 250°C). The appropriate microplugs are also available, with tools and instructions for mounting in the kit UA 0129. See Accessories.

3.2. OUTPUT

If the output is taken via a miniature cable, an adapter may be necessary to feed the output signal to the next instrument. An alternative BNC output socket is available for connection to the input of the analyzing and indicating instrumentation. In the DIRECT output mode, the signal could be off-set by max. ± 10 mV. When the preamplifier is used in a servo-loop in exciter systems, the TRANSFORMER output mode may advantageously be used since the output is floating. Problems arising from ground loops can thus be avoided. Care should, however, be taken with this output below 40 Hz and above 10 kHz. Below 40 Hz the available output amplitude is limited by saturation of the transformer iron at a rate of 6 dB/octave. Above 10 kHz large capacitive loads may introduce peaking effects.

3.3. POWER REQUIREMENTS

The preamplifier can be operated from any line voltage between 90 and 265 Volts AC, without adjustments required for the instrument. Maximum power consumption is approximately 7 Watts.

3.4. OVERLOAD RESET

The use of this button restores immediately normal operating conditions after overload when the preamplifier is used in low frequency modes for impulse (shock) measurements.

3.5. USE IN SERVO LOOPS OF EXCITER CONTROL SYSTEMS

On account of quick recovery time the preamplifier can be used in servo loops in exciter systems. It should be noted, however, that it is dangerous to unplug loads or alter switch positions during a vibration test, as sudden changes in levels could occur at the exciter table resulting in damage to the specimen or the table itself.

3.6. LOW FREQUENCY MEASUREMENTS

Special care should be taken when low frequency measurements are carried out. Piezoelectric ceramic accelerometers on account of pyroelectric effects will yield a low frequency output when subjected to temperature variations. Since the frequency response of the Preamplifier can go down to 0.3 Hz, these low frequency variations can be seen on the output of the amplifier. To eliminate this effect, the position of the selector giving the highest possible low frequency cut-off should be used as a general rule. If wide temperature fluctuations are encountered, Quartz Acc. Type 8304 should be used.

3.7. HUM & NOISE REDUCTION

For correct operation of the instrumentation, the effects of hum and noise fields should be cut down to a minimum. The following remarks may help as a useful guide in reducing the effects.

Avoid earth loops through which serious hum problems could arise. Make the screen of the output cable the only connection between the preamplifier and the following instruments. If the main transformer in a power amplifier has considerable capacitance between its windings, it is best to ground the amplifier, making this the one and only earth point in the system. Since most accelerometers have their casing as one connection, they must be isolated from the test object if it is grounded by a metal structure. If the transformer output of the Preamplifier Type 2626 is used, this is not necessary. For minimizing wind-induced noise, an efficient draught shield can be of great help, even in an apparently still room. If necessary an accelerometer of higher charge sensitivity may be used.

3.8. EVALUATION OF NOISE REFERRED TO INPUT

Noise in a charge amplifier is dependent upon active input devices and input source capacitance C_s (consisting of transducer capacitance and cable capacitance). For evaluation of the noise the feedback capacitance C_f of the amplifier and input noise must be known. As the Conditioning Amplifier Type 2626 has a Field Effect Transistor input stage, only the voltage noise e_n has to be considered for an approx. calculation of wide band noise, Fig.3.1.

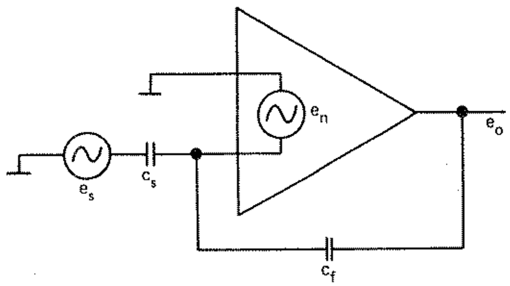


Fig.3.1. Input stage of amplifier

The charge amplifier output noise can be calculated from

$$e_o = e_n \frac{(C_s + C_f)}{C_f}$$

If the noise is referred to input source the expression should be divided by the signal gain

$$\frac{e_o}{e_s} = \frac{C_s}{C_f}$$

i.e. $e_{ns} = e_n \frac{(C_s + C_f)}{C_s}$ where e_{ns} is the noise referred to input.

The noise charge q_{ns} referred to input is therefore

$$q_{ns} = e_{ns} \times C_s = e_n \ (C_s + C_f)$$

The value of e_n for the Preamplifier Type 2626 is max. 5 μV RMS in a 100 kHz frequency band. The feedback capacitance C_f which is dependent on the position of the output sensitivity switch is given in Table 3.1.

RANGE	V/g			
1 – 10 pC/g	.001	.01	.1	1
10 – 100 pC/g	.01	.1	1	10
100 – 1000 pC/g	.1	1	10	
C_f (nF)	10	1	0.1	0.1

Table 3.1. Feedback capacitance C_f as a function of control settings

To illustrate the evaluation of the noise referred to input the following example is included in which a piezoelectric accelerometer Type 4338 is used.

Acc. Capacitance	1000 pF
Acc. Sensitivity	100 pC/g
Acc. Cable Capacitance	100 pF (1.2 meter cable length)
Amplifier Output Sensitivity	1 V/g
Preamplifier Range	10–100 pC/g
Noise charge referred to input	$= q_{ns} = e_n (C_s + C_f)$ $= 5 \times 10^{-6} (1000 + 100 + 100) \times 10^{-12}$ $= 6 \times 10^{-15}$ C $= 6 \times 10^{-3}$ pC.

Converting input noise charge to acceleration for a sensitivity of 100 pC/g gives 6×10^{-5} g or 60 μg referred to input. With 1 V/g sens. this is equal to 60 μV RMS at the output. From the above calculations it is obvious that a combination of a high sensitivity accelerometer and use of high gain in the amplifier will yield the best S/N ratio. With large cable lengths, however, the noise is to a great extent determined by the cable. Furthermore the cable itself will produce considerable noise when exposed to mechanical vibration (Tribo-electric effect). Therefore for low level measurements low noise cables should be used and must be rigidly supported between the accelerometer and the preamplifier.

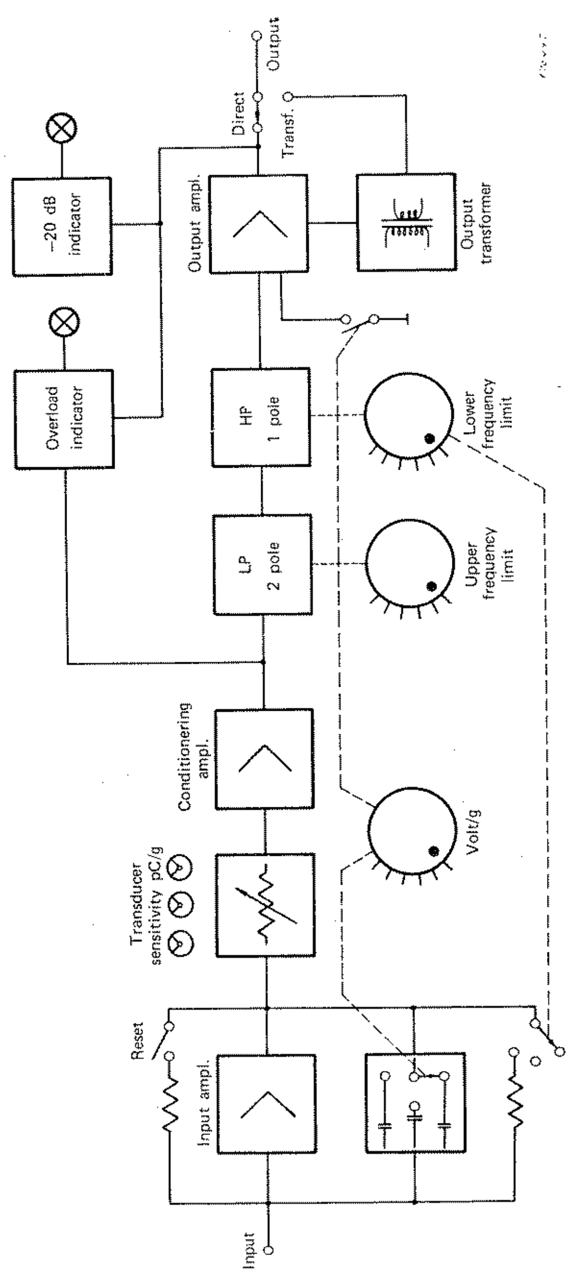


Fig.4.1. Block diagram of Conditioning Amplifier Type 2626

4. DESCRIPTION

A block diagram of the Preamplifier is shown in Fig.4.1.

The Preamplifier Type 2626 consists of

1. 3 amplifier stages: input, conditioning and output.
2. Low pass and high pass filters.
3. Output transformer.
4. Signal level indicator (overload and 20 dB from overload)
5. Power supply.

4.1. INPUT

The input amplifier is an operational amplifier with high loop gain and capacitive feedback. A dual FET transistor is chosen for the input of the operational amplifier for low noise and low input current. Three different input sensitivities can be selected on account of the different feedback capacitors in the three lowest positions of each transducer range (Volt/g switch). It is thus possible to have gain in the input stage giving the best signal-to-noise ratio. With for example 1000 pF transducer capacitance, a closed loop gain of 0.1, 1, and 10 respectively is obtained.

For DC stabilizing of the amplifier the feedback capacitor is coupled in parallel with a resistor. This RC combination determines the lower limiting frequency of the amplifier. Since the resistor is changed simultaneously with the capacitor, the lower limiting frequency is independent of the sensitivity settings. With the "Reset" button the resistor can be coupled parallel to a low resistor so that when low frequency shock causes overload, the amplifier can be quickly reset. For DC overload the recovery time is determined by the lower limiting frequency. Since the recovery time for impulse overloading is insignificant, the amplifier can be used in the servo-loop of exciter systems without danger of blocking. The input amplifier has its own printed circuit in the left side of the cabinet (as viewed from the front).

4.2. CONDITIONING SECTION

The three switches for "Transducer Sensitivity" are placed on a printed circuit together with the conditioning resistors. 0.1% resistors are used for the most significant digit (left switch) so that an overall accuracy of 0.5% may be maintained for all settings. The Conditioning Amplifier is built using low noise transistors. The closed loop gain is determined by a fixed feedback resistor and the conditioning resistors.

4.3. FILTERS

The low pass filter is an active 2-pole Butterworth filter. Since the cut-off rate is 12 dB/octave, the transducer resonance can be damped without destroying significantly the frequency response below resonance. The "Upper Frequency Limit" switch changes the two frequency determining capacitors in the filter. The high pass filter is a single pole 6 dB/octave RC filter. It isolates input off-set voltages from the output amplifier so that the output always has a zero DC voltage (within a few mV) and simultaneously decouples low frequency signals, temperature drift, etc.

4.4. OUTPUT

The output amplifier is an operational amplifier with a Field-Effect Transistor input. The amplifier is non-inverting and since the first two stages are inverting, the signal passes through the instrument without inversion of phase. The output amplifier can feed at least 10 mA and is stabilized so that it can be loaded with long cables without instabilities. With the "Lower Frequency Limit" switch in one of the DIRECT output positions, the output signal goes directly to the output socket and the feedback of the amplifier is taken from the output line. In the TRANSFORMER output mode the output signal is fed to the primary side of the output socket. The feedback, which is of great importance for linear reproduction of the low frequencies, is taken from a special feedback winding. The secondary of the transformer is floating and has therefore no galvanic contact to the chassis, thus avoiding ground loops in servo-control of exciter systems. The gain of the output amplifier is unity in the three lowest positions and 10 in the maximum position of each transducer range.

4.5. SIGNAL LEVEL INDICATORS

The overload indicator, which lights just before clipping, consists of two symmetrical triggering circuits, one for positive and one for negative signals. The circuits are triggered by a short impulse, approx. 10 μs, and are supplied with delay so that the lamp is lit for approx. 2 seconds. The overload indicator can be triggered also when the filters are used indicating a possible overload of the first two stages.

The "20 dB from Overload" indicator consists of a differential amplifier which works as a phase inverter and has a triggering circuit similar to the one used for the overload indicator. The lamp lights for approx. 2 seconds after triggering.

The gain (in Volts/g) should be set such that the "20 dB from Overload" lamp is lit at normal signal levels without the "Overload" lamp lighting at the highest signal peaks. This gives the best signal-to-noise ratio.

4.6. POWER SUPPLY

Power supply is taken from AC line voltage. Voltages from 100 to 240 V (± 10%) can be used directly without adjustments. The power supply delivers regulated ± 15 V to the amplifier, filters and level indicator circuits, and a high DC voltage for the decimal point and level indicating lamps. While the voltage for the decimal point lamp is not regulated, the voltage for the level indicator lamps is regulated by a Zener diode.

4.7. OUTPUT CHARACTERISTICS

The frequency response of the preamplifier is influenced by loading of the input and the output. Fig.4.2 shows the upper frequency limits for different output loads and output voltages. The curves show the response for a large signal (20 $V_{peak-peak}$) and a low signal (2 $V_{peak-peak}$). Fig.4.3 shows the upper frequency limits for different input loads and sensitivity settings.

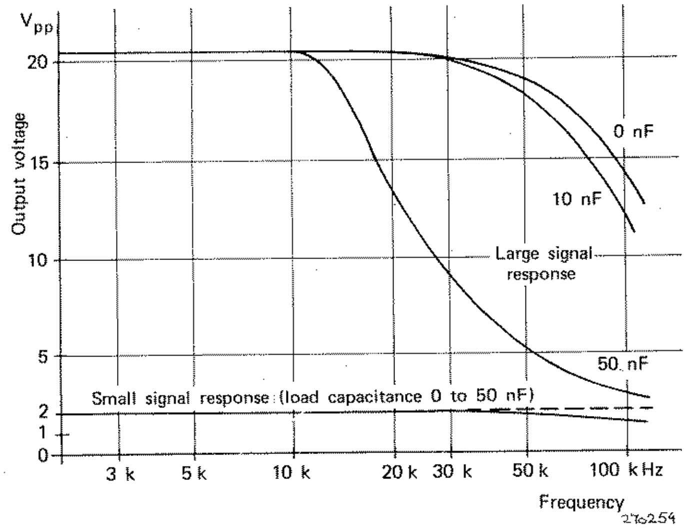


Fig.4.2. Upper frequency limits for different output loads (Distortion approx. 1%)

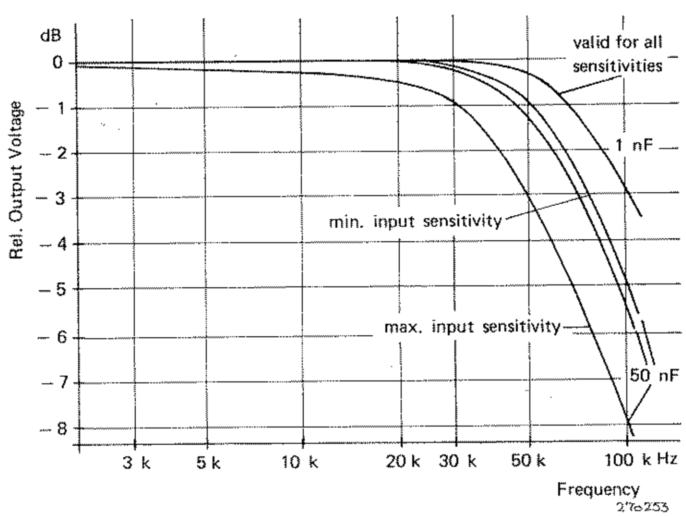


Fig.4.3. Upper frequency limits for different source capacitances and input sensitivities

4.8. NOISE

The noise level in the Preamplifier Type 2626 in the frequency range 2–100,000 Hz is shown in Fig.4.4 as a 1/3 octave spectrum analysis. For the calculation of noise levels in practical operation see section 3.8.

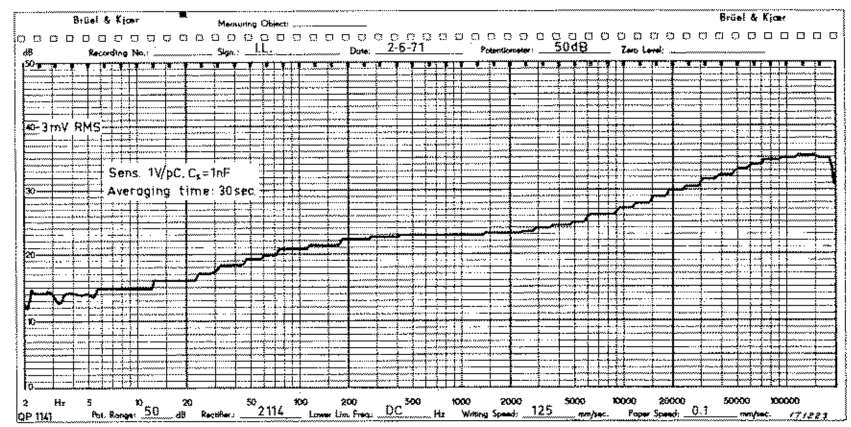


Fig.4.4. Spectrum of inherent noise

4.9. PHASE CHARACTERISTICS

Phase shift in the preamplifier is determined by the high and low pass filters. For most measurements where phase shift is of any importance, the upper frequency limit can be chosen high enough so that the phase shift due to the low pass filter is insignificant.

The phase shift introduced by the lower frequency limit can easily be calculated as the filter is of the first order type (6 dB/octave roll off). The phase characteristic of a single RC section is given by

$$\tan \emptyset = \frac{f_c}{f}$$

where f_c is the filter cut-off frequency, and f is the frequency of interest.

If for example the frequency of interest is 10 times the cut-off frequency the absolute phase shift is

$$\tan^{-1} \; 0.1 \simeq 5.7^{\circ}$$

If two amplifiers are used and the outputs compared (as is in the case of calibration of accelerometers utilizing a Sensitivity Comparator Type 2970) the resulting phase error is the difference between the individual phase shifts of the two amplifiers.

When the tolerance of the cut-off frequency is known the maximum phase difference can be calculated from

$$\tan \Delta \emptyset = \left(\frac{\frac{f_{c1}}{f} - \frac{f_{c2}}{f}}{1 + \frac{f_{c1}\, f_{c2}}{f^2}} \right)$$

where f_{c1} and f_{c2} are the individual cut-off frequencies. The two lowest lower limiting frequencies in the amplifier are dependent on high ohmic resistors which are not available with close tolerances. In the worst case of one filter with deviation + 10% and the other with −10% the phase difference has been calculated for various frequencies using the above formula

For $f = 10\, f_c$ $\quad \Delta \emptyset = 1^{\circ}$

$f = 3\, f_c$ $\quad \Delta \emptyset = 3.5^{\circ}$

5. USE WITH OTHER INSTRUMENTS

5.1. SENSITIVITY CALIBRATION OF ACCELEROMETERS

On account of the phase characteristics of the Conditioning Amplifier Type 2626 it is well suited for calibration of accelerometers when used in conjunction with a Sensitivity Comparator Type 2970, and Vibration Exciter Type 4801 fitted with the Calibration Head Type 4815.

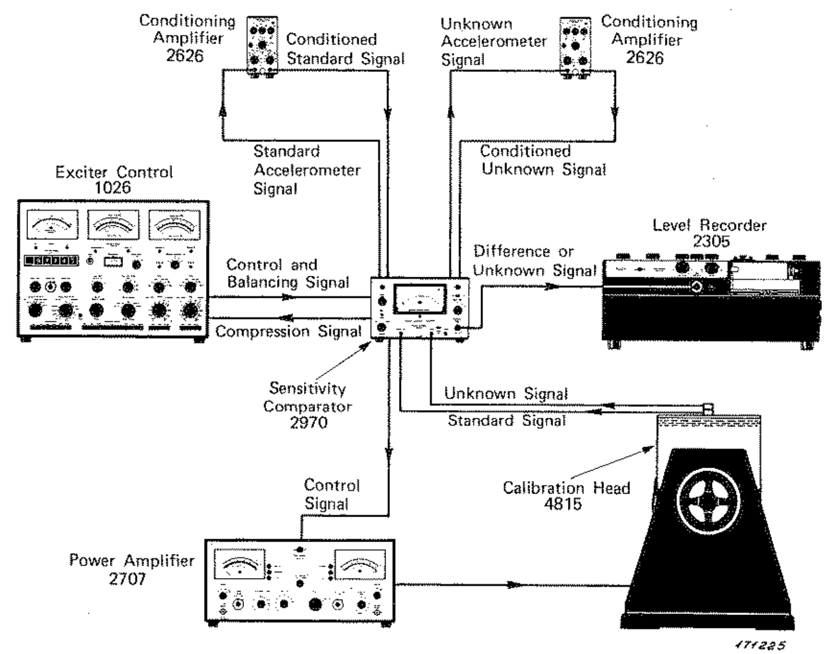


Fig.5.1. Measuring arrangement for calibration of accelerometers

The accelerometer to be calibrated is mounted on the Calibration Head which has a built-in reference accelerometer. It is driven to the calibration level, usually the level at which the unknown accelerometer is to be used,

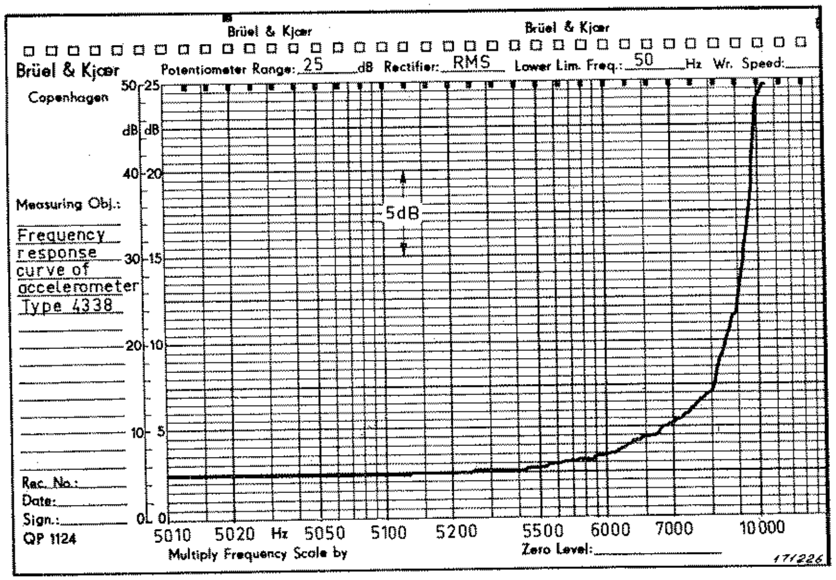


Fig.5.2. Frequency response curve of unknown accelerometer

and the accelerometer signals are fed to the comparator via two individual Conditioning Amplifiers, Fig.5.1. The basic circuit of the Sensitivity Comparator is a summation amplifier which can be balanced by two equal and opposite inputs. The gain of the Conditioning Amplifier in the unknown accelerometer line is adjusted to achieve the balance condition indicated by zero deflection on the built-in meter. The actual charge sensitivity of the unknown accelerometer can be read directly off the Conditioning Amplifier in the unknown accelerometer line, if the reference channel is correctly adjusted. The voltage sensitivity of the accelerometer can also be obtained by utilizing a converter switch on the Sensitivity Comparator. Calibration of the accelerometer can be made up to levels of 100 g peak, in the frequency range 60–250 Hz. If a frequency response curve of the unknown accelerometer is desired, the FUNCTION SELECTOR switch on the comparator is used in the "Record" position. In this case the reference accelerometer signal is removed from the input of the summation amplifier, but remains connected to the compressor circuit of the Exciter Control to maintain the acceleration level constant at the exciter. The unknown signal passes through the instrument in the normal way but is extracted before the filter section and appears at the recorder output socket on the front panel. If now the Vibration Exciter Control is swept through the frequency range of the

test accelerometer, a frequency response curve relative to the response curve of the reference accelerometer can be obtained on the Level Recorder Type 2305, Fig.5.2.

5.2. WIDE BAND RANDOM TEST

The three basic reasons why the wide band random vibration test has become popular as a qualification type of vibration test are:

1. The vibration producing mechanisms found in nature are more often of a random type than of a sinusoidal type and a random vibration test therefore simulates the statistical character of common vibration environment better than does a sweeping sine wave test.

2. The wide band random test excites all specimen resonances simultaneously so that possible interaction effects are accounted for.

3. The wide band test-time required for a certain test exposure has orders of magnitude smaller than any single frequency sweep test.

A test of this type was carried out on a rectangular bar to determine its resonant frequencies. The test set-up is shown in Fig.5.3 and consists of a multi-band Equalizer-Analyzer System Type 3380 driving the Exciter Body/General Purpose Head Type 4801/4812 combination via the Power Amplifier Type 2707. The excitation level was kept constant on the exciter head by means of a control accelerometer and a Conditioning Amplifier Type 2626 in the compressor loop.

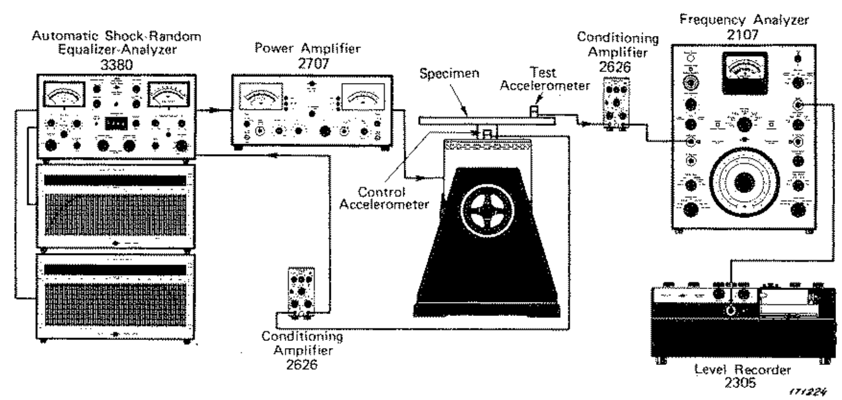


Fig.5.3. Measuring arrangement for wide-band random test

To avoid loading the specimen, a miniature accelerometer was mounted for analyzing the response of the bar. The signal was analyzed and recorded by means of the Frequency Analyzer Type 2107 and Level Recorder Type 2305. A spectrum obtained is shown in Fig.5.4.

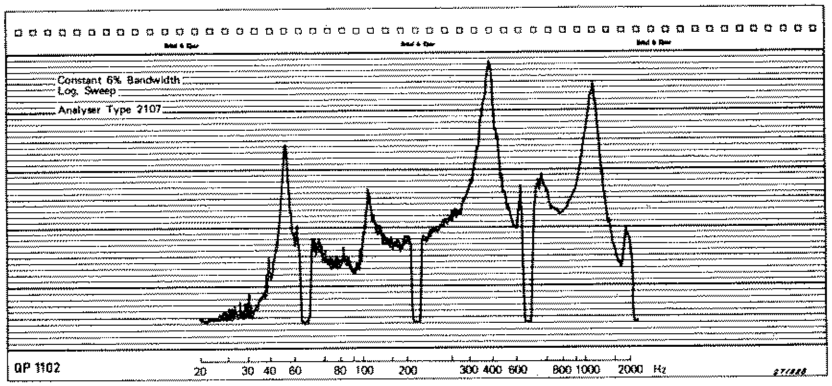


Fig.5.4. Frequency spectrum of specimen

5.3. MECHANICAL IMPEDANCE MEASUREMENTS

Mechanical impedance measurements are possible with the conditioning amplifiers on account of the duplicating phase characteristics of the amplifier. Using the impedance head and two conditioning amplifiers, one for the force transducer and the other for the accelerometer, the output signals may be processed simultaneously to yield the mechanical impedance at the point of measurement.

5.4. CORRELATION MEASUREMENTS

The Conditioning Amplifier is also suitable for correlation measurements where the vibration at two different points on a structure is under investigation. Correlation functions or cross-power spectra are computed to find sources of vibration, transmission paths, etc.

6. ACCESSORIES

Accelerometer cables with plugs fitted are available from Brüel & Kjær in 1.2 m (4 ft.) lengths. When the distance between accelerometer and amplifier is longer than 1.2 m, the required cable must be made up individually. Coaxial mininoise accelerometer cable is available in lengths up to 200 m (600 ft.). The miniature plugs and tools for fitting them to the cable are also available. (Figs.6.1 and 6.2). The following ordering numbers should be used:

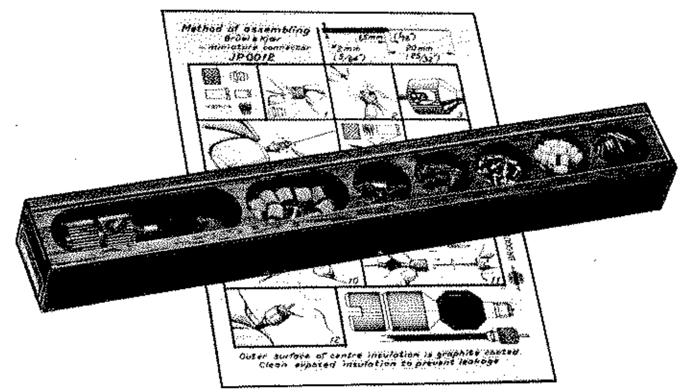


Fig.6.1. The UA 0129 set containing plugs tool, and instructions for mounting the plugs

AO 0037	1.2 m (4 ft.) of mininoise cable for operation to 100°C (212°F) fitted with miniature plugs. Individually calibrated.
AO 0038	1.2 m (4 ft.) of mininoise cable for operation to 260°C (500°F) fitted with miniature plugs. Individually calibrated.
AC 0010	Mininoise PVC insulated accelerometer cable up to 600 ft. in one length. 90 pF/m or 30 pF/ft. for operation to 100°C (212°F).

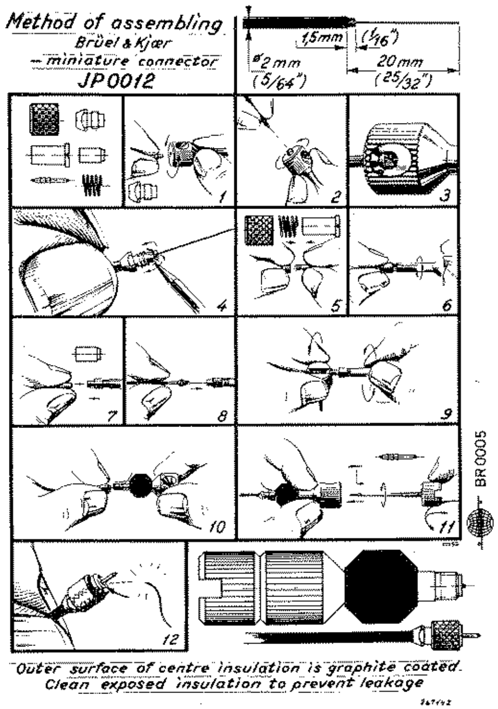


Fig.6.2. Instruction leaflet for mounting the plugs

AC 0005 Mininoise teflon insulated accelerometer cable up to 600 ft. in one length. 90 pF/m (30 pF/ft.), for operation to 260°C (500°F).

UA 0125 Set of studs containing 10 isolated studs YS 0420, 10 steel studs YQ 2960, 10 nuts YM 0414, 10 mica washers YO 0534.

UA 0142 1 set of clamping magnets containing 5 permanent magnets UA 0070 with isolated mounting.

UA 0129 Set of 20 miniature plugs JP 0012 with tools and instruction for mounting of the plugs on cable.

UA 0130 Set of 25 miniature plugs JP 0012.

7. SPECIFICATIONS

INPUT: Charge Amplifier, single ended.
Max. input signal without clipping at lowest input sensitivity: 10^5 pC.

SENSITIVITY: For calibrated positions.

Transducer Sens.	Output Volt/g
1 – 10 pC/g	0.001, 0.01, 0.1, 1
10 – 100 pC/g	0.01, 0.1, 1, 10
100 – 1000 pC/g	0.1, 1, 10

CONDITIONING: 3 digits transducer sensitivity setting.

ACCURACY: ±0.5% at 1 kHz and ±1% at 10 kHz for the 2 lower gain positions in each transducer range when input load is less than 0.06 μF and 0.02 μF respectively.

1% change in gain for input load of approximately 0.2 and 0.1 μF respectively.

±1% at 1 kHz and ±2% at 10 kHz for other gain positions when input load is less than .006 μF.

1% change in gain for approximately .015 μF.

FREQUENCY RANGE:

Direct Output: 0.3 Hz–100 kHz (3 dB down).

Transformer Output: Lower Limit: 0.3 Hz (3 dB down) 1 Hz (5% down).

Upper Limit: depends on capacitive load at output. See Figs.4.2 and 4.3.
With 3 nF load, peaking is less than 1% at 10 kHz.

OUTPUT:

Direct Output

Voltage/current: 10 V_{peak}, 10 mA, 0.3 Hz – 30 kHz.
DC off-set: max. ± 10 mV.
Impedance: 1 Ω below 10 kHz at 3 lowest gain positions.
10 Ω below 10 kHz at max. gain.

Transformer Output

Voltage/current: 10 V_{peak}, 10 mA, 40 Hz – 30 kHz.
Below 40 Hz transformer output voltage capability is reduced at a rate of 6 dB/octave. At 1 Hz the output voltage swing is approx. 0.4 $V_{peak-peak}$.
Impedance: 12 Ω at 3 lowest gain positions
22 Ω at max. gain.

NOISE:

in 100 kHz bandwidth:
5 μV RMS referred to input + 4 μV RMS/1000 pF source capacitance. See also Fig.4.4.
Max. increase in noise 6 dB in a 100 A/m 50 Hz magnetic field.

FILTERS:

High Pass

Slope 6 dB/octave.
3 dB down: 0.3, 3, 10, 30 Hz.
5% down: 1, 10, 30, 100 Hz.
Tolerance 20% for the 1 lower positions, 10% otherwise.

Low Pass

Slope 12 dB/octave.
3 dB down: 1, 3, 10, 30, 100 (Lin) kHz less than 5% (typical 2.5%) at 0.3, 1, 3, 10, 30 kHz.
Tolerance ± 10%.

HARMONIC DISTORTION:

1% at full output and capacitive load of 50 nF at frequencies below 10 kHz.

LEVEL INDICATORS:

Overload

Indicator lights when the signal is more than 10 V_{peak} but before clipping occurs.
Sensitive for short impulses.
Delay approximately 2 sec.

−20 dB

Indicator lights when the signal is between 1 V_{peak} and full output.
Sensitive for short impulses.
Delay approximately 2 sec.

RECOVERY:

For an impulse overload of 5000 pC/1 msec. and for max. gain the recovery time is max. 200 μsec.

POWER SUPPLY:

100–240 V AC (± 10%) & Frequency 50–400 Hz. Consumption approx. 7 watts, at max. mains voltage.

TEMPERATURE RANGE:

Operation −10 to + 55°C
Storage −25 to + 70°C.

MECHANICAL DATA:

Cabinet: B & K module KK 0022
Height: 132.6 mm (5.22 in)
Length: 200 mm (7.87 in)
Width: 69.5 mm (2.74 in)
Weight: 1.75 kg (3.89 lb).