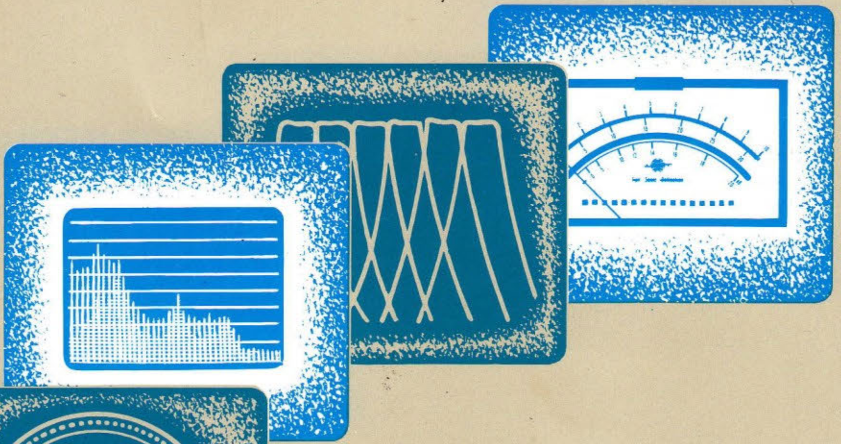
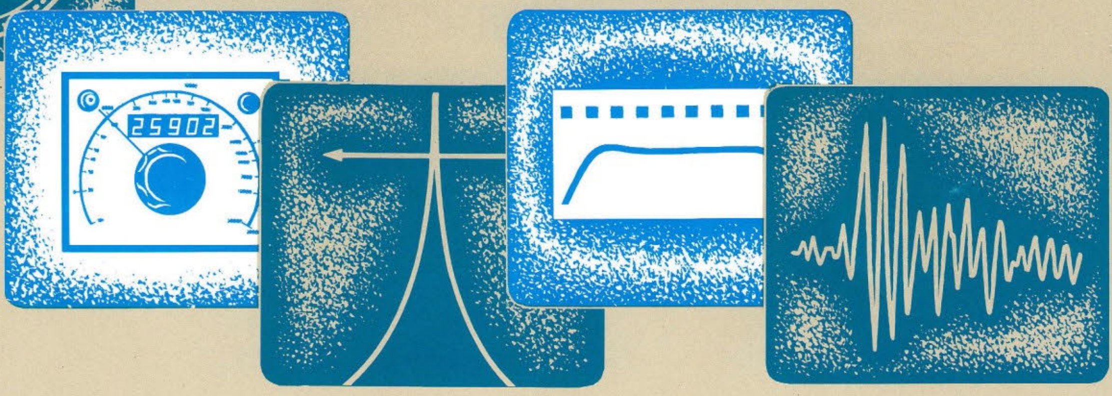
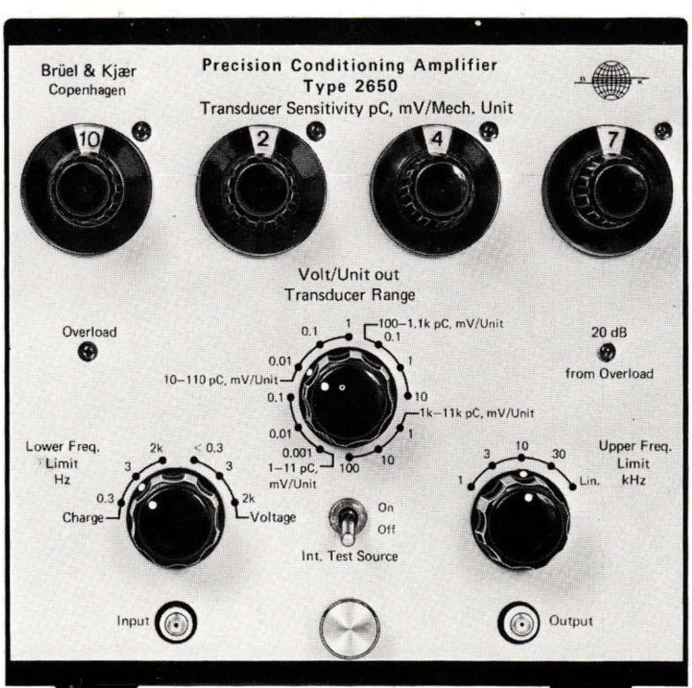


2650

Instruction Manual



Precision Conditioning Amplifier Type 2650



A charge and voltage preamplifier for piezoelectric vibration transducers and hydrophones. Accurate 4 digit conditioning permits dial-in of exact transducer charge or voltage sensitivity from 1 to 11000 pC or mV/unit to give unified output ratings between 0,001 and 100 volts/unit which are selectable in decade steps.

Brüel & Kjær

033-0060

PRECISION CONDITIONING AMPLIFIER
TYPE 2650

Revision April 1979

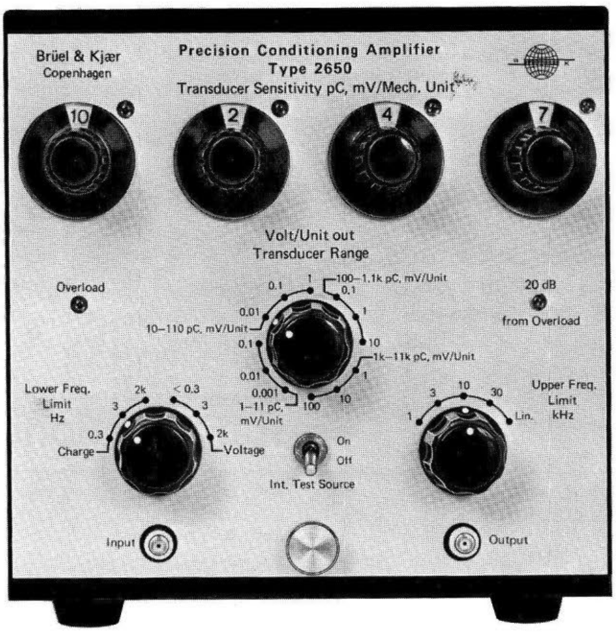
CONTENTS

type 2650

Precision Conditioning Amplifier

FEATURES:
- Charge and voltage input modes
- 4 digit conditioning to transducer sensitivity
- Unified output ratings for simplified system calibration
- Sensitivity up to 100 mV/pC or mV/mV
- Switchable low and high frequency limits
- Built-in test oscillator

USES:
- Comparison calibration of piezoelectric transducers
- General purpose vibration measurements
- Underwater sound measurements with hydrophones



The Transducer Calibration Amplifier Type 2650 is mainly intended for the calibration of piezoelectric vibration transducers. The Amplifier is equipped with a 4 digit conditioning network which directly shows the sensitivity of the transducer under calibration when used together with a reference transducer, amplifier channel (2626), and the comparator Type 2970. Furthermore, Type 2650 is ideal for use with Hydrophones, especially the Standard Hydrophone Type 8100. For this purpose it is equipped with a standard B & K coaxial socket on the rear panel, and a special filter position to reject LF noise which is sometimes troublesome when calibrating in water tanks. It is able to work as a charge amplifier as well as a voltage amplifier and it features unified output ratings in both modes. It is equipped with overload and signal level indicator lamps and has a very short recovery time.

Description

As can be seen from the block diagram in Fig. 1 the 2650 consists of an input amplifier, a 1000 Hz oscillator, a filter section, a conditioning section and an output amplifier.

Input Stage

The 2650 is equipped with a high-gain, low-noise operational FET amplifier in the input stage. In the voltage mode it provides a high input impedance giving minimum loading of the accelerometer and thereby securing a high accuracy. In the charge mode it eliminates the influence of capacitance from long cables as it is only sensitive to changes in charge. The sensitivity of the stage is variable, giving a

BP 0199–12

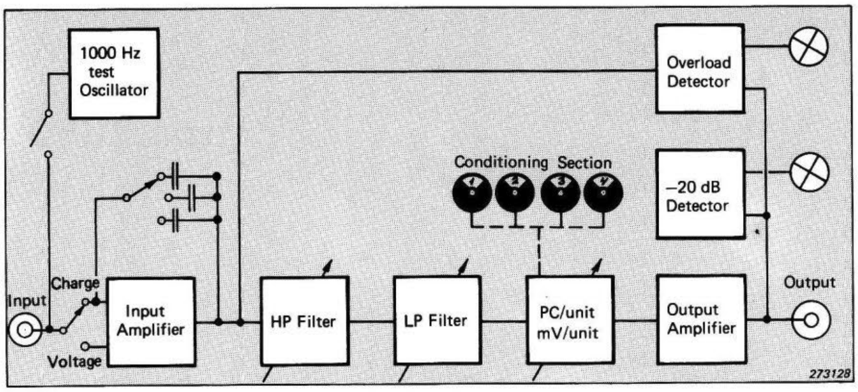


Fig.1. Block diagram of the 2650

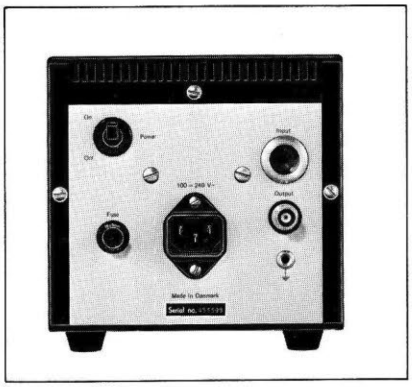


Fig.2. Rear panel of the 2650

rated output in the range 1 mV to 100 V/measurement unit. The obtainable output voltage depends on the sensitivity of the transducer. For calibration purposes, a 1000 Hz oscillator can be connected to the input of the stage.

Filter Section

From the input amplifier the signal is passed to the active high-pass and low-pass filters. Both filters have a cut-off slope of 40 dB/decade and selectable cut-off frequencies.

Conditioning Network

A four-digit transducer conditioning network enables the amplifier sensitivity to be matched exactly to the sensitivity of the transducer, thus providing a directly calibrated output in volts/measurement unit. When the 2650 is combined with a reference transducer, an amplifier channel (for instance the Conditioning Amplifier Type 2626) and the Comparator Type 2970 the four digits provide a direct read-out of the sensitivity of the unknown transducer.

Output Stage

Finally, the signal enters the output stage which secures a low output impedance. Two level indicators are provided. One indicates overload at the input or output stages, while the other indicates when the signal level is within 20 dB of full output. These help in selecting a suitable sensitivity setting for maximum output signal with minimum output noise.

Specifications 2650

CHARGE AND VOLTAGE INPUTS:
Via 10-32 NF and standard B & K coaxial sockets
Max. Input: ~10^5 pC and 10 V peak respectively
Input Impedance: 5 GΩ//10 pF (voltage input only)

SENSITIVITY CONDITIONING:
4 digit dial-in of transducer sensitivity from 1,0 to 1099 pC/unit

AMPLIFIER SENSITIVITY:
0,1 to 100 mV/pC or mV/mV corresponding to −20 to +40 dB with transducer capacitance of 1 nF

CALIBRATED OUTPUT RATINGS:
1 mV to 100 V/unit selectable in 20 dB steps

ACCURACY:
For low and intermediate V/UNIT OUT settings of each transducer range: ±0,25% from 20 Hz to 10 kHz for input loads less than 10 nF
For high V/UNIT OUT setting of each transducer range: ±0,5% from 100 Hz to 10 kHz for input loads less than 10 nF

SIGNAL OUTPUT:
Via 10-32 NF and BNC coaxial socket

Max. Output: 10 V (10 mA) peak
DC Offset: ±10 mV
Output Impedance: < 1 Ω

FREQUENCY RANGE:
0,3 Hz to 100 kHz

LOW–PASS FILTER:
Switchable −3 dB upper frequency limits of 1 kHz, 3 kHz, 10 kHz, 30 kHz and Lin ~200 kHz with attenuation slope of 40 dB/decade except for Lin mode

HIGH–PASS FILTER:
Switchable −3 dB lower frequency limits of 0,3 Hz, 3 Hz and 2 kHz with attenuation slope of 40 dB/decade

DISTORTION: <2%

INHERENT NOISE (2 Hz to 22 kHz)
5 10^{-3} pC or 5 μV RMS referred to input with maximum sensitivity and 1 nF transducer capacitance

TEST OSCILLATOR:
1 kHz sinusoid factory preset for test level of 1 V

LEVEL INDICATORS:
"Overload" LED lights when input or output level exceeds 10 V peak
"20 dB from Overload" LED lights when output level is between 1 and 10 V peak

RISE TIME: ~3 V/μs

RECOVERY TIME: ~200 μs

ENVIRONMENTAL CONDITIONS:
Temperature Range: −10 to +55°C (+14 to 131°F)
Humidity: 0 to 90% RH (non-condensing)

POWER REQUIREMENTS:
100 to 240 V (50 to 400 Hz) ±10% AC. 5 VA. Complies with Safety Class I of IEC 348

DIMENSIONS:
Height: 132,6 mm (5,22 in)
Width: 139,5 mm (5,53 in)
Depth: 200 mm (7,87 in)
B & K module cassette KK 0024, 4/12 of 19 in rack module

WEIGHT: 1,5 kg (3,3 lb)

ACCESSORIES INCLUDED:
1 × Power Cable .... AN 0010
1 × BNC to B & K Input Adaptor .... JP 0144
1 × 50 mA Fuse .... VF 0016

2. CONTROLS

2.1. FRONT PANEL

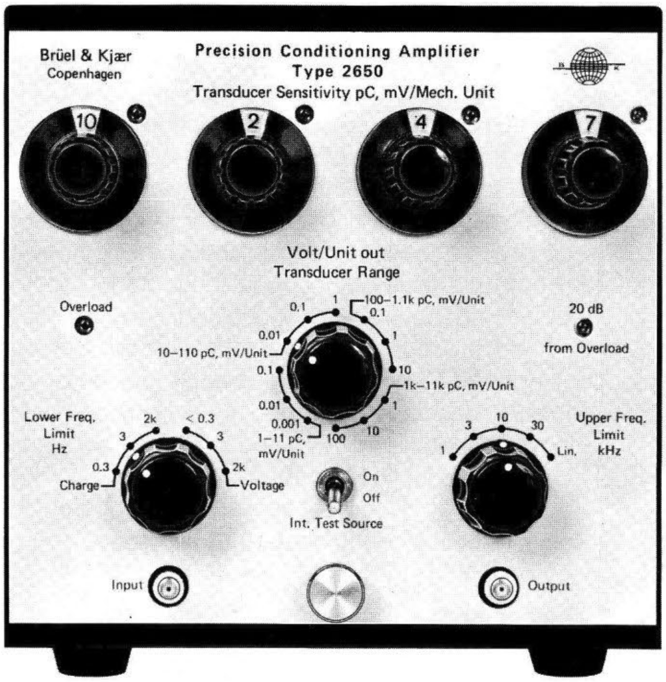


Fig.2.1. Front panel of 2650

TRANSDUCER SENSITIVITY pC, mV/Mech. Unit:

Four knobs for "dial-in" of exact transducer charge or voltage sensitivity from 1,000 to 10999 pC, mV/Mechanical Unit. With the exact sensitivity dialed in, the output sensitivity of the 2650 is conditioned to that selected with the VOLT/UNIT knob. Decimal place indication is given by one of three lamps above the TRANSDUCER SENSITIVITY knobs.

VOLT/UNIT OUT:

12 position switch which, depending on transducer sensitivity, is used to select output ratings ranging from 0,001 to 100 V/Mech. Unit.
The maximum sensitivity available is 100 mV/pC (100 mV/mV)
The minimum sensitivity available is 0,1 mV/pC (0,1 mV/mV)

LOWER FREQ. LIMIT:

For selection of "Charge" or "Voltage" mode with lower cut off frequencies (3 dB down) of "0,3 Hz", "3 Hz" and "2 kHz". The cut off slope is 40 dB/decade.

UPPER FREQ. LIMIT:

For selection of "1 kHz", "3 kHz", "10 kHz", "30 kHz" and "Lin." (200 kHz) upper cut off frequencies (3 dB down). The cut off slope is 40 dB/decade.

INT. TEST SOURCE: With this switch set to "On" the output of an internal test source producing a stabilized 1 Vpeak, 1 kHz sine wave signal is applied to the INPUT sockets on the front and rear panels. The signal can be used in checking the correct function of the 2650, as well as a reference for determination of absolute levels with tape recorded data. See section 3.3.

INPUT: Microdot socket accepting B & K accelerometer cables for connection of a transducer. With the "Charge" mode of the LOWER FREQ. LIMIT switch the maximum input charge rating is 100 nC. With the "Voltage" mode the maximum input voltage rating is 10 V peak, and input impedance is 5 GΩ in parallel with 10 pF.

OUTPUT: Microdot socket accepting B & K accelerometer cables for connection of measuring and analyzing equipment. The socket is DC coupled and has an output impedance of less than 1 Ω. The maximum output with the low sensitivity setting in each transducer range of the VOLT/UNIT OUT switch is 2 V (10 mA) peak in the "Voltage" mode and 10 V (10 mA) peak in the "Charge" mode. With intermediate and high sensitivity settings the maximum output is 10 V (10 mA) peak in the "Voltage" as well as the "Charge" mode.

The maximum DC offset voltage at the socket is ± 50 mV, but can be adjusted to within more precise limits as in section 3.1.3.

OVERLOAD: An indicator lamp which lights on overload when the input or output level exceeds 10 V peak.

20 dB FROM OVERLOAD: An indicator lamp which lights when the output level exceeds 1 V peak (i.e. —20 dB re 10 V peak).

2.2. REAR PANEL

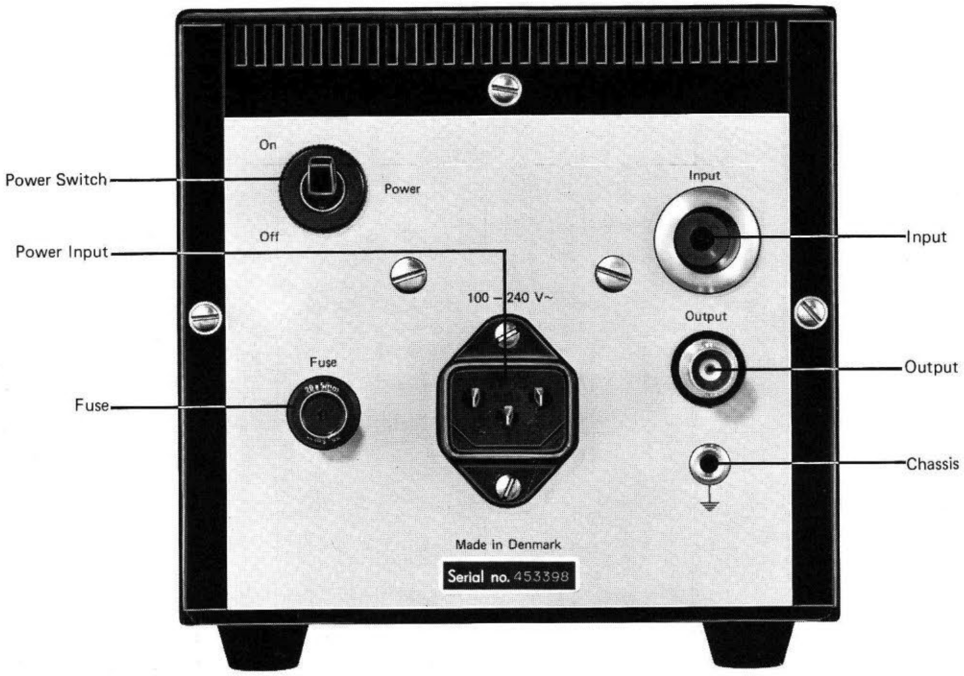


Fig.2.2. Rear panel of 2650

POWER SWITCH:	"On"/"Off" switch for power. When set to "On" and a mains supply is connected to the POWER INPUT socket of the instrument, one of the decimal place indicators above the TRANSDUCER SENSITIVITY pC, mV/Mech. Unit knobs should light indicating that the 2650 is powered.
POWER INPUT:	Input socket accepting the power cable AN 0010 provided for connection of a mains supply as in section 3.1.1. Any line voltage between 100 and 240 V, 50 to 400 Hz AC can be used. The maximum power consumption is 6 VA.
POWER FUSE:	Contains 50 mA slow blow mains fuse (B & K stock no. VF 0016). For replacement of the fuse the knob of the fuse holder may be unscrewed and pulled out with the fuse.
INPUT:	An alternative input connected in parallel with the input socket on the front panel. Accepts B & K coaxial plugs JP 0101 or the Microdot plug adaptor JP 0028.
OUTPUT:	An alternative output connect in parallel with the output socket on the front panel. Accepts a BNC plug (B & K stock no. JP 0035) or the BNC to Microdot Adaptor JP 0052.
CHASSIS:	Socket accepting a banana plug (B & K stock no. JP 0002) for connection of the chassis to ground. See "Grounding Considerations" section 3.1.2.

3. OPERATION

3.1. PRELIMINARY

3.1.1. Connection of Mains Supply

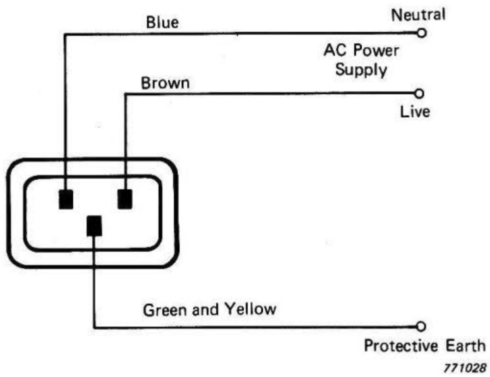


Fig.3.1. Connection of mains supply to POWER INPUT socket

The 2650 may be powered from any 100 to 240V (50 to 400Hz) single phase AC mains supply - no voltage setting adjustments are required. To fit a suitable mains plug to the power cable AN 0010 provided, see Fig.3.1. For maximum operating safety, the protective (green/yellow) conductor of the power cable should be connected to the protective earth contact of a mains socket outlet. The use of extension cables without protective conductor should be avoided.

Note: In countries where the use of a mains socket outlet without protective conductor is standard, the mains supply should incorporate an authorized earth leakage current circuit breaker.

3.1.2. Grounding

Hum pick-up by ground loops can cause considerable measurement inaccuracies. To prevent this it is essential that the 2650 and other instruments with which it is used are properly grounded. This can be done as follows:

1. Connect the signal ground lines of all instruments together. This is automatically done through the screens of the coaxial cables connecting the input and output sockets of the instruments.

2. If the outer casing of the measurement transducer is connected to signal ground as is the case with many vibration transducers, then isolate it from grounded measurement points.

3. Connect the signal ground of one of the instruments to its chassis and then connect the chassis to mains ground. It is essential that this is done on only one of the instruments and preferably the one nearest the measurement source.

4. Make the necessary adjustments such that the chassis of each of the other instruments is connected to one and only one of the following: a) mains ground, b) signal ground or c) chassis ground of another instrument which must eventually be connected to mains ground.

The 2650 is delivered with its signal ground connected to chassis. To disconnect signal ground from chassis, as might be necessary to conform with the above grounding requirements, remove the connection plate shown in Fig.3.2. This is located on the print board immediately behind the right side panel of the 2650. Before attempting to remove the panel or change the signal ground chassis connection, disconnect the 2650 from the mains supply. To connect chassis to mains ground see Fig.3.1.

⚠ **WARNING:** The 2650 is designed to be operated with its signal ground lines and chassis, always at earth potential. Never let the signal ground terminals, socket screens or chassis float at any other potential, as this will impair the operating safety of the 2650 and may damage it as well as the other instruments with which it is used.

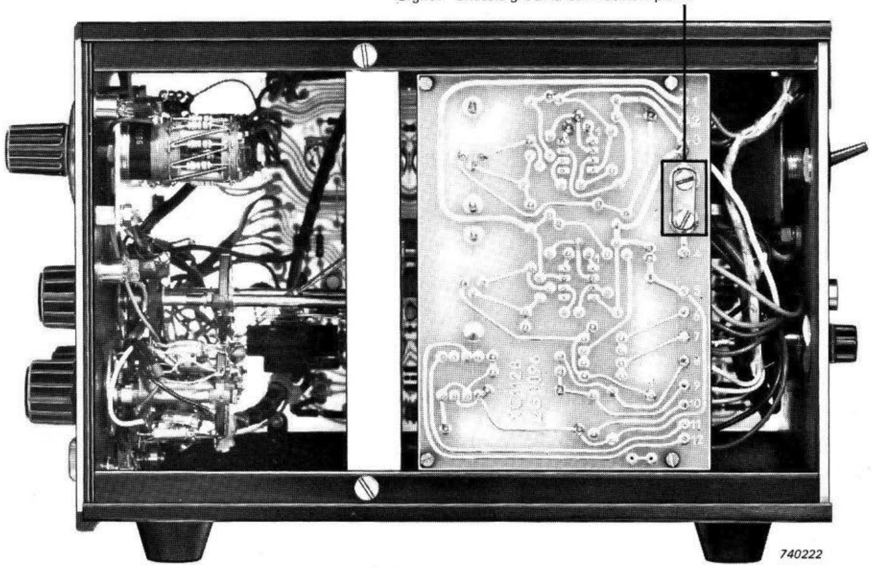


Fig.3.2. Signal ground-chassis ground connection on 2650

3.1.3. Adjustment of Output DC Offset Voltage

The maximum DC offset voltage at the outputs of the 2650 is adjusted at the factory to within ± 10 mV and further adjustment is not normally necessary. However, if at some time it is found necessary to check or adjust the DC balance of the output signal then this should be done as follows:

1. Remove the two side panels of the 2650 by sliding them towards the rear of the instrument. The panels are fastened by screws on the rear panel.

2. Check that the signal ground line of the 2650 is connected to chassis. This is done as in section 3.1.2. After making the check replace the right side panel.

3. Connect the POWER INPUT socket to a suitable mains supply, set the POWER SWITCH to "On" and wait a few minutes for the 2650 to warm up. If the POWER INPUT socket is not connected to mains ground (see Fig.3.1), ground the chassis of the 2650 by connecting its CHASSIS socket to a suitable earth e.g. water pipe.

4. With the INT. TEST SOURCE switch set to "Off", set the LOWER FREQ. LIMIT switch to "Charge" or "Voltage" depending on the preamplifier mode for which the DC offset adjustment is to be made.

5. Terminate one of the INPUT sockets with a 1 nF capacitor and to one of the OUTPUT sockets connect a sensitive DC voltmeter such as the Digital B & K Type 2427.

6. Using a small insulated screwdriver adjust the preset potentiometer P_2 (see Fig.3.3) so that the output DC offset voltage indicated by the voltmeter is zero.

7. Disconnect the mains supply and replace the left side panel making the 2650 ready for use.

⚠ **WARNING:** Disconnect all mains power from the 2650 before attempting to remove or replace its protective panels. Internal adjustments with mains power connected, should be carried out only by skilled persons who are aware of the hazards of dealing with live circuitry.

Output DC offset adjustment P_2

Fig.3.3. Output DC offset adjustment potentiometer P_2

3.2. USE AS MEASUREMENT PREAMPLIFIER

3.2.1. Measurement arrangement

For general purpose measurements the 2650 may be used with the range of B & K Piezoelectric Transducers, Voltmeters, Measuring Amplifiers and Frequency Analyzers shown in Fig.3.4. The unified output ratings obtained with 4 digit dial-in of transducer charge and voltage sensitivity on the preamplifier are accurate to with 0,25%* and therefore for measurements only the indicating instrument used need be calibrated.

* ± 0,25% accuracy with low and intermediate output sensitivity settings in each transducer range of the VOLT/UNIT OUT switch. ± 0,5% with high sensitivity settings.

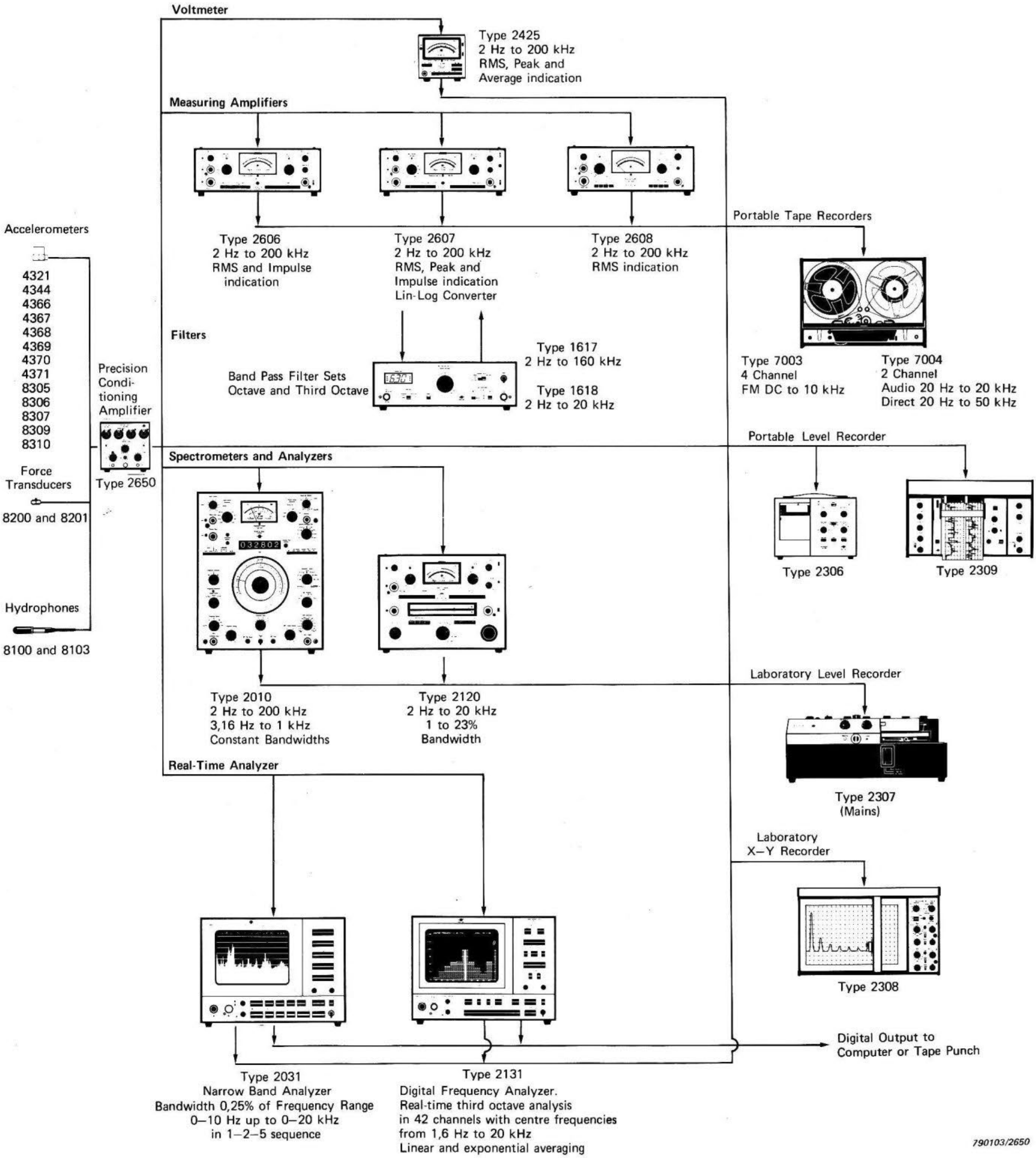


Fig.3.4. The range of B & K piezoelectric transducers and measuring instrumentation that may be used for vibration and sound pressure measurements with the 2650

The connection of a 2650 into a measuring arrangement will depend on the preamplifier mode selected with its LOWER FREQ. LIMIT switch.

"Charge" The 2650 together with the other measuring instrumentation may be operated close to or far away from the measurement point. Virtually any length of cable may be used to connect the transducer to the 2650 without the capacitance of the cable influencing the charge sensitivity of the transducer specified on its calibration chart.

"Voltage" The 2650 should be operated in the immediate vicinity of the measurement point. A cable of length and capacitance specified by the calibration chart of the transducer may then be used to connect the transducer to the 2650 without altering the voltage sensitivity of the transducer specified on the calibration chart. If a longer cable with capacitance other than that specified is used, a new voltage sensitivity will have to be calculated as in item 8 of the measurement procedure given in section 3.2.2.

3.2.2. Measurement Procedure

For measurements the basic operating procedure is as follows:

1. Carry out the preliminary adjustments necessary as in section 3.1.

2. With the INT. TEST SOURCE switch set to "Off" connect a suitable mains supply to the POWER INPUT socket of the 2650 and set its POWER SWITCH to "On". One of the indicator lamps above the SENSITIVITY pC, mV/unit knobs should now light indicating that the 2650 is powered.

3. Connect the INPUT socket of the Voltmeter, Measuring Amplifier or Frequency Analyzer to be used as the indicating instrument in the measuring arrangement, to one of the two OUTPUT sockets on the 2650. Either the Microdot OUTPUT socket on the front panel or the BNC OUTPUT socket on the rear panel may be used.

4. Calibrate the indicating instrument for non-selective (linear mode) voltage measurements as prescribed in the Instruction Manual for the instrument. After calibration select the 10V full scale deflection range of the instrument with the appropriate RMS or Peak meter function for measurements.

5. Observing the mounting and installation instructions given in the Instruction Manual for the measurement transducer, connect the transducer to one of the two INPUT sockets of the 2650. To prevent hum pick-up the INPUT socket not in use should be shielded. For this purpose the Screening Cover YM 0420 with or without the Microdot Adaptor JP 0028 may be used.

6. Using the UPPER FREQ. LIMIT switch, select the lowest cut off frequency above the highest measurement frequency of interest to keep high frequency noise to a minimum.

7. Using the LOWER FREQ. LIMIT switch select the "Charge " or "Voltage" preamplifier mode with a suitable low frequency cut off for measurements.

   Low frequency, temperature variation induced noise with accelerometers may be suppressed using the "3 Hz" setting. For suppression of hum and vibration signals picked up by hydrophones when used in water tank applications select the "2 kHz" setting.

8. Starting with the most significant digit SENSITIVITY pC, mV/Unit knob and ignoring the decimal place indication, dial in the Charge or Voltage sensitivity of the transducer appropriate to the preamplifier mode selected in item 7.

The charge sensitivity value to be dialed in is that given by the calibration chart of the transducer employed. It is not influenced by cable capacitance as is the voltage sensitivity which is also given by the chart, but for a cable of specified length and capacitance. If a longer cable is used with capacitance other than that specified then the voltage sensitivity value to be dialed in will have to be calculated using the relation:

$$S_V = \frac{S_Q}{C_t + C_c}$$

Where

S_V is the voltage sensitivity of the transducer (mV/Mech. Unit)
S_Q is the charge sensitivity of the transducer specified by its calibration chart (pC/Mech. Unit)
C_t is the capacitance of the transducer specified by its calibration chart (pF)
C_c is the capacitance of the cable connecting the transducer to the 2650 (pF)

Example 1:

If a piezoelectric accelerometer with charge sensitivity of 62 pC/g and capacitance of 1014 pF is connected to the 2650 via a 10 m long cable with capacitance of 90 pF/m, then the transducer's voltage sensitivity to be set on the 2650 when its "Voltage" mode is selected is:

$$S_V = \frac{62}{1014 + 10(90)} = 0{,}032 \text{ V/g}$$

$$S_V = 32{,}00 \text{ mV/g}$$

Example 2:

If a piezoelectric hydrophone with charge sensitivity of 0,2 pC/Pa (i.e. 200.10^{-3} pC/Pa) and capacitance of 7000 pF (including 7,2 m of cable) is connected to a 2650 via a 50 m long extension cable with capacitance of 90 pF/m, then the transducer voltage sensitivity to be set on the 2650 when its "Voltage" mode is selected is given by:

$$S_V = \frac{0{,}2}{7000 + 50(90)} = 0{,}01742 \text{ mV/Pa}$$

$$S_V = 17{,}42\ \mu\text{V/Pa}$$

9. Using the VOLT/UNIT OUT switch select a transducer sensitivity range in which the lamps above the four TRANSDUCER SENSITIVITY knobs indicate the correct decimal place with the value of transducer sensitivity set with the knobs.

   Within each transducer range of the VOLT/UNIT OUT switch low, intermediate and high output sensitivity settings may be selected in clockwise order.

10. Using the VOLT/UNIT OUT switch select an output sensitivity setting within the transducer range selected in item 9 that causes the "20 dB from Overload" (not "Overload") indicator to light when the signal to be measured is applied.

If the "20 dB from Overload" indicator fails to light then select the high output sensitivity setting (furthest clockwise position in the transducer range selected).

11. Set the measurement range of the indicating instrument to obtain a suitable meter deflection without overload.

12. The level of the measured signal may now be read directly from the meter. The signal amplitude corresponding to full scale deflection on the meter is given by:

$$L_{FSD} = \frac{V_{FSD}}{V_u} K$$

where L_{FSD} = signal amplitude for full scale meter deflection (Unit of measured signal i. e. g, N, Pa etc.)

V_{FSD} = Voltage for full scale deflection of indicating instrument (V).
V_u = Volt/Unit out value selected on 2650
K = 1 when transducer sensitivity value set on 2650 is in pC/Unit or mV/Unit
or K = 10^3 when transducer sensitivity value set on 2650 is in 10^{-3} pC/Unit or μV/Unit

For measurements using piezoelectric hydrophones it is usual to express Sound Pressure Level (SPL) in dB re 1 μPa. The SPL for full scale meter deflection (SPL_{FSD}) with L_{FSD} calculated as above (in pascals)

$$SPL_{FSD} = 20 \log L_{FSD}(10^6) \quad \text{dB re } 1\mu\text{Pa}$$

$$= 120 + 20 \log L_{FSD} \quad \text{dB re } 1\ \mu\text{Pa}$$

Similarly for sound pressure level measurements using microphones it is common to express SPL in dB re 20 μPa, so with L_{FSD} in pascals:

$$SPL_{FSD} = 20 \log \frac{L_{FSD}}{2 \cdot 10^{-5}} \quad \text{dB re } 20\ \mu\text{Pa}$$

or $$SPL_{FSD} = 94 + 20 \log L_{FSD} \quad \text{dB re } 20\ \mu\text{Pa}$$

Example 1:

If an accelerometer with voltage sensitivity 0,614 mV/g (i. e. 614 μV/g) is used for vibration measurements with a SENSITIVITY pC, mV/Unit knob setting of 614,0 and VOLT/UNIT OUT switch setting of 10 then the acceleration level corresponding to full scale meter deflection on the indicating instrument when the 3,16 V_{peak} measurement range is used is given by:

$$L_{FSD} = \frac{3,16}{10} 10^3$$

$$L_{FSD} = 316\ g_{Peak}$$

Example 2:

If a hydrophone with voltage sensitivity of 0,01742 mV/Pa (i. e. 17,42 μV/Pa) is used for SPL measurement with a SENSITIVITY pC, mV/Unit knob setting of 17,42 and VOLT/UNIT OUT switch setting 1 then the sound pressure for full scale meter deflection on the indicating instrument when 3,16 mV measurement range is used is given by:

$$L_{FSD} = \frac{3{,}16 \cdot 10^{-3}}{1} 10^3$$

$$L_{FSD} = 3{,}16 \text{ Pa}$$

Therefore $$SPL_{FSD} = 120 + 20 \log 3{,}16$$

$$SPL_{FSD} = 130 \text{ dB re } 1\ \mu\text{Pa}$$

Alternatively $$SPL_{FSD} = 94 + 20 \log 3{,}16$$

$$SPL_{FSD} = 104 \text{ dB re } 20\ \mu\text{Pa}$$

3.3. USE OF INTERNAL TEST SOURCE

The internal test source may be used in checking the correct function of the 2650 and as a reference for determining the levels of measured signals recorded on tape. It is connected to the input stage of the Amplifier using the INT. TEST SOURCE switch on the front panel and with the control settings prescribed in Table 3.1 produces a 1 kHz sinusoidal signal with voltage level of 0,1; 1 or 10 V (RMS or Peak) at the OUTPUT sockets of the Amplifier.

VOLT/UNIT OUT setting					TRANSDUCER SENSITIVITY setting 10 000	7 071
Transducer Range pC, mV/unit	1-11	10-110	0,1-1,1 k	1-11 k	Test Voltage Vpeak	Test Voltage Vpeak
Volt/Unit	0,1 0,01 0,001	1 0,1 0,01	10 1 0,1	100 10 1	10 1 0,1	– 1 0,1

740364

Table 3.1. Internal test voltage output levels for different control settings on the 2650

To check the correct function of the 2650, a voltmeter or other indicating instrument may be used to measure the test voltage. With the control settings prescribed in Table 3.1 the test voltage output levels should be accurate to within ± 2%.

For determining absolute levels with tape recorded measurements, first record the measured signal from the output of the 2650 and then record the 0,1; 1 or 10 V test voltage. Provided that the input sensitivity of the recorder is kept the same for both recordings, then on playback the amplitude of the recorded test signal will correspond to a vibration level or sound pressure given by

$$L_t = \frac{V_s}{V_{OUT}} K$$

where L_t = is the equivalent vibration level (g) or sound pressure (Pa) of the test signal on playback

V_s = is the test voltage level (volts) recorded (see Table 3.1)

V_{OUT} = is the VOLT/UNIT OUT setting used for recording the measurement

and K = is 1 when transducer sensitivity is dialed in on the 2650 in pC/unit or mV/unit

or K = is 10^{-3} when transducer sensitivity is dialed in on the 2650 in 10^{-3} pC/unit or 10^{-3} mV/unit.

4. MEASUREMENT CHARACTERISTICS

4.1. FREQUENCY AND PHASE CHARACTERISTICS

The frequency and phase response characteristics of the 2650 are shown in Figs.4.1 and 4.2. These are chiefly determined by the high and low pass filters of the instrument which may be selected using the LOWER and UPPER FREQ. LIMIT switches. For the majority of applications where good phase linearity is of importance these switches may be set so that the phase shift within the frequency range of interest is insignificant.

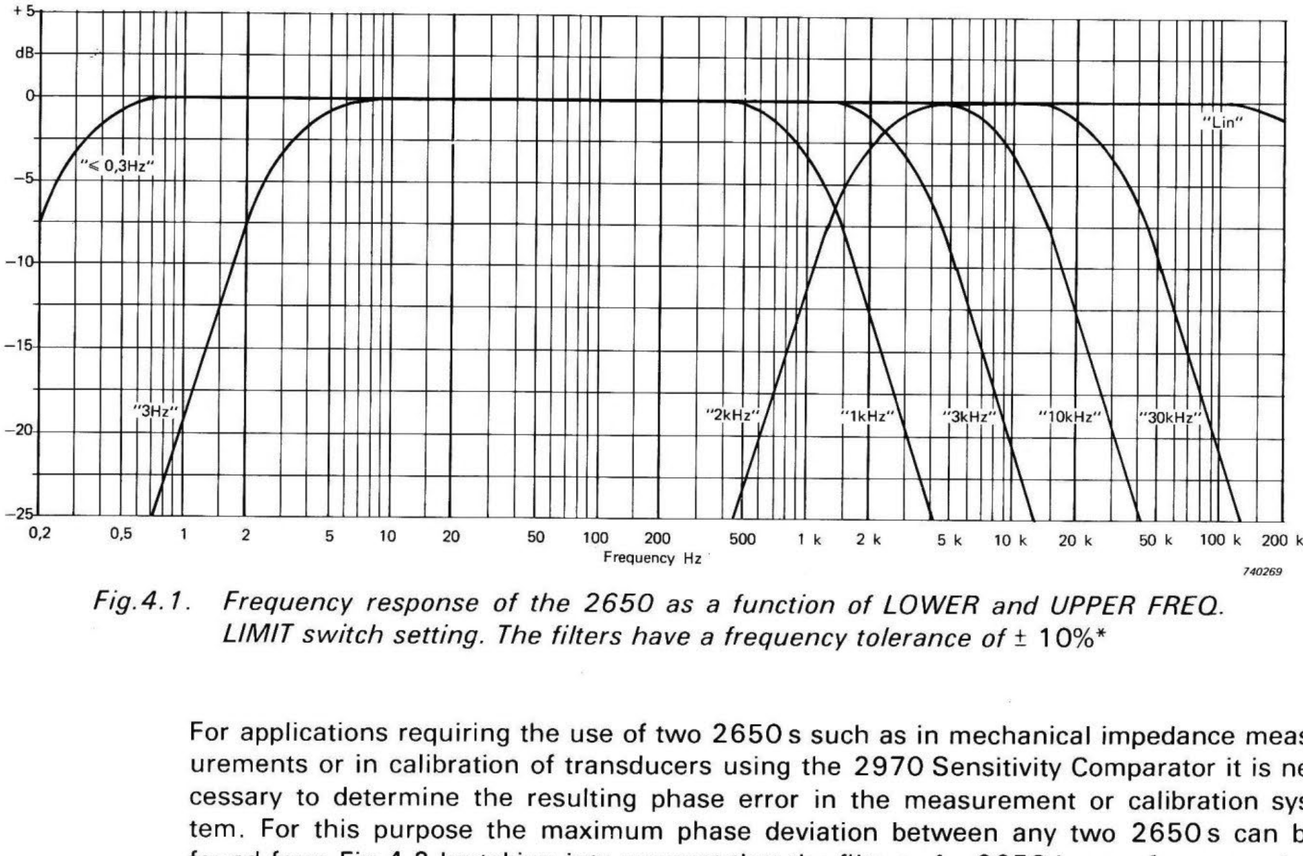


Fig.4.1. Frequency response of the 2650 as a function of LOWER and UPPER FREQ. LIMIT switch setting. The filters have a frequency tolerance of ± 10%*

For applications requiring the use of two 2650 s such as in mechanical impedance measurements or in calibration of transducers using the 2970 Sensitivity Comparator it is necessary to determine the resulting phase error in the measurement or calibration system. For this purpose the maximum phase deviation between any two 2650s can be found from Fig.4.2 by taking into account that the filters of a 2650 have a frequency tolerance of ± 10%*.

---

* ± 20% with 0,3 Hz and 0,2 Hz ("< 3") LOWER FREQ. LIMIT switch settings.

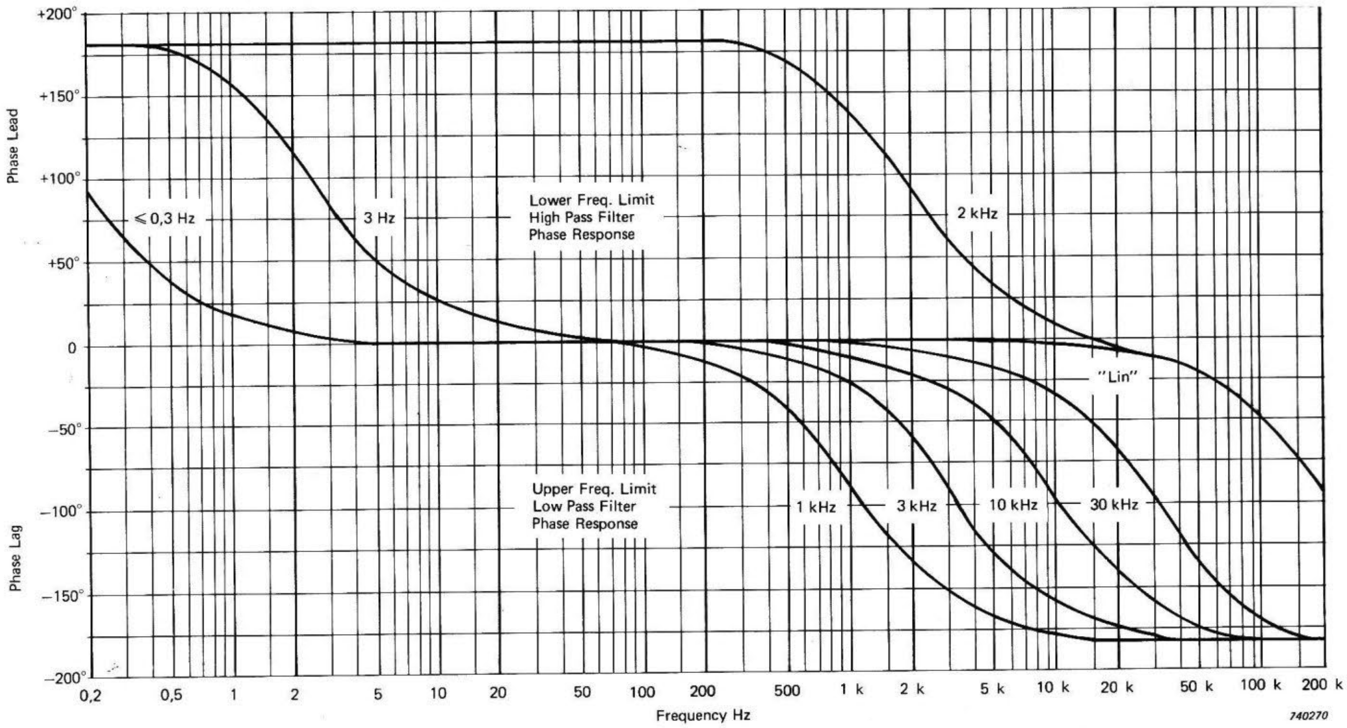
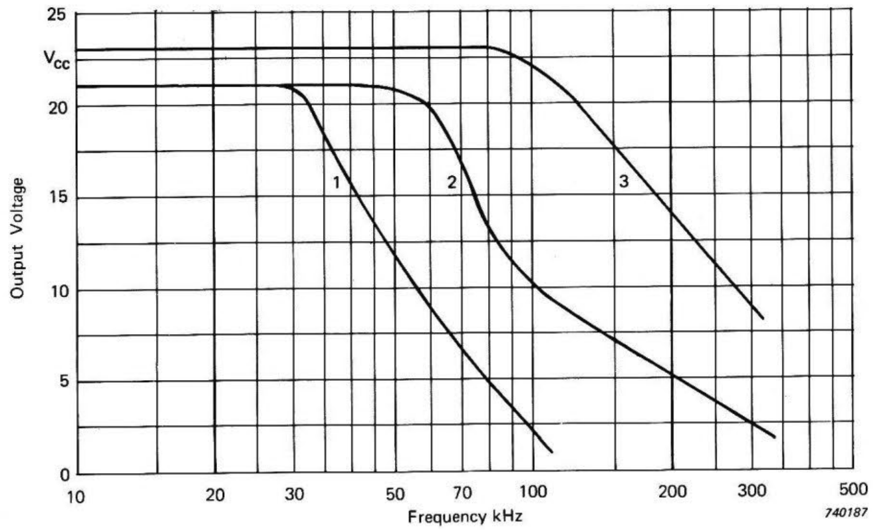


*Fig.4.2. Phase response of the 2650 as a function of LOWER and UPPER FREQ. LIMIT switch setting. The filters have a frequency tolerance of ± 10%**

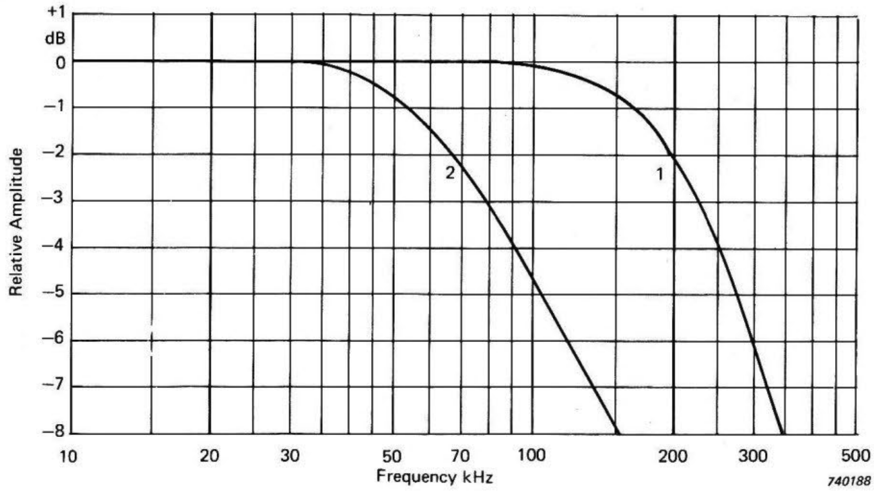
4.2. INFLUENCE OF INPUT AND OUTPUT LOADS

The frequency response of the 2650 is influenced by different input and output loads as well as by its SENSITIVITY and VOLT/UNIT OUT switch setting. This is shown by the



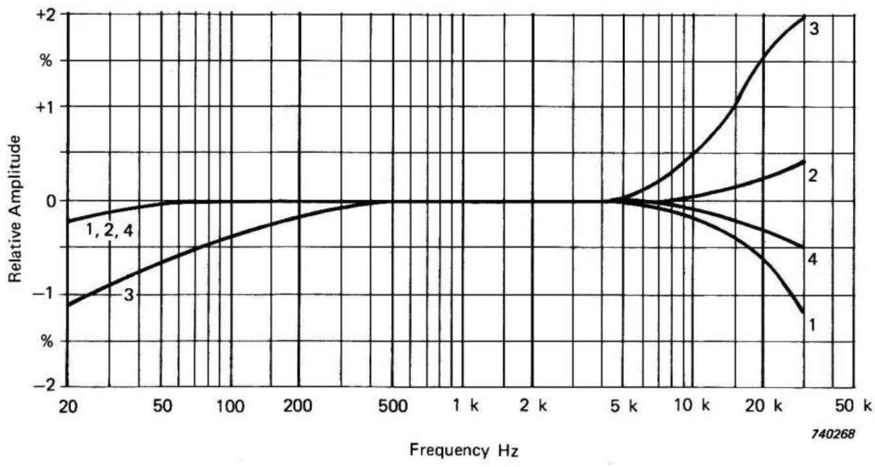
Curve	Output Load	Conditioning Setting
1	10 nF	10,000
2	1 nF	10,000
3	300 pF	3,000

Fig.4.3. Large signal output characteristics (2% distortion) showing upper frequency limits for different output loads with Charge and Voltage modes



Curve	Mode	Input Load	Volt/Unit Out Sens. Setting
1	Charge	1 nF	Any setting
1	Charge	10 nF	Low and Intermediate
1	Voltage	0 to 10 nF	Any setting
2	Charge	10 nF	High

Fig.4.4. Small signal output characteristics (< 2% distortion) showing upper frequency limits for different input loads with Charge and Voltage modes



Curve	Mode	Input Load	Sensitivity Setting	Volt/Unit Out Sens. Setting
1	Charge	10nF	1,000	Low
2	Charge	10nF	10,000	Intermediate
3	Charge	5nF	10,000	High
4	Voltage	0 to 10nF	10,000	All settings

Fig.4.5. Small signal output characteristics (< 2% distortion) showing influence of different input loads with Charge and Voltage modes

large signal output (2% distortion) response curves in Fig.4.3 which give the high frequency limits for maximum output from the amplifier with different output loads. In the "Voltage" mode attenuation of the Amplifier's output signal to obtain the low sensitivity setting in each VOLT/UNIT OUT switch range limits the maximum output level to approximately 2 V peak to peak. For this setting in the "Charge" mode as well as for intermediate and high sensitivity settings the output signal is not attenuated enabling a maximum output level of approximately 20 V peak to peak to be obtained.

The influence of input load on the frequency response of the 2650 is shown by the small signal output (≤ 2% distortion) response curves given in Fig.4.4 and 4.5. At low frequencies input loading has virtually no effect on the response even when the "Voltage" mode used. This is of special importance as with most types of voltage preamplifier the lower limiting frequency response is very much dependent on input load.

4.3. OUTPUT NOISE

Broadband 2 Hz to 300 kHz output noise levels produced by the 2650 when operated in its "Charge" and "Voltage" modes are specified in Table 4.1. With the preamplifier set for maximum sensitivity and with a source capacitance C_s of 1 nF terminating its input, a maximum noise level of 1 mV is produced, representing a minimum signal to noise ratio better than 60 dB. For higher values of source capacitance, noise produced in the "Charge" mode increases, while noise produced in the "Voltage" mode decreases. A typical third octave analysis of the preamplifier's noise spectrum is shown in Fig.4.6.

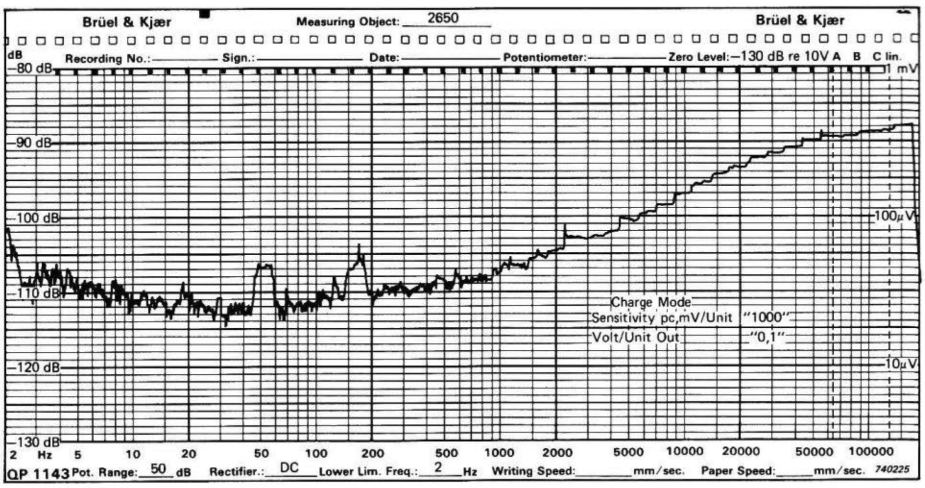


Fig.4.6. Third octave analysis of noise spectrum produced by 2650 with a source capacitance of 1 nF

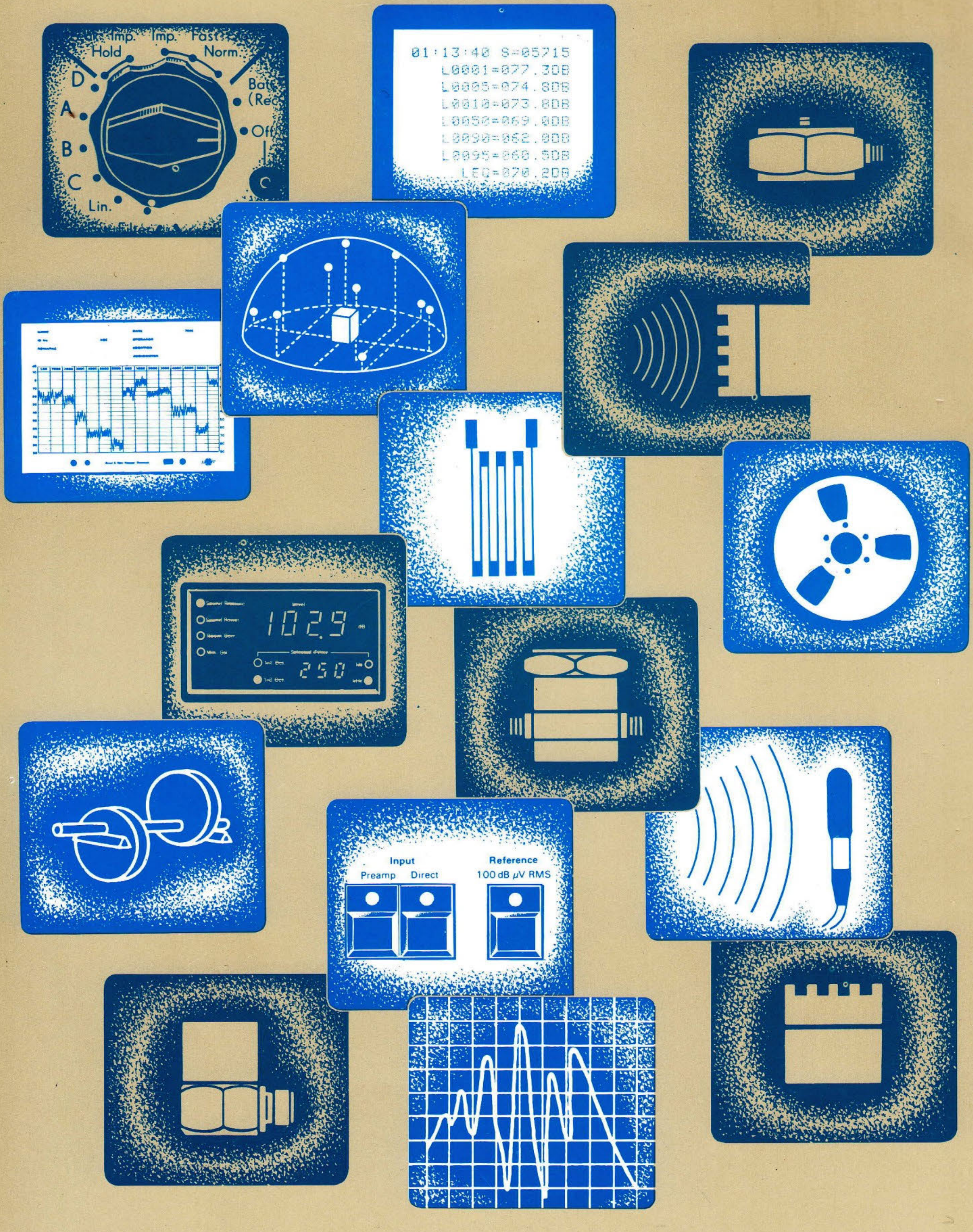
VOLT/UNIT OUT Setting	SENSITIVITY pC, mV/unit Setting	Broadband Output Noise (2 Hz – 300 kHz)		
		VOLTAGE MODE $C_s > 1$ nF	CHARGE MODE 1 nF $< C_s <$ 10 nF	CHARGE MODE $C_s >$ 10 nF
0,001	10,000	< 60 μV	60 μV + 0,2 μV/nF of C_s	60 μV + 0,2 μV/nF of C_s
	1,000	< 350 μV	350 μV + 2 μV/nF of C_s	350 μV + 3 μV/nF of C_s
0,01	10,000	< 60 μV	60 μV + 4 μV/nF of C_s	60 μV + 6 μV/nF of C_s
	1,000	< 350 μV	310 μV + 40 μV/nF of C_s	310 μV + 60 μV/nF of C_s
0,1	10,000	< 100 μV	100 μV/nF of C_s	100 μV/nF of C_s
	1,000	< 1 mV	1 mV/nF of C_s	1 mV/nF of C_s

740365

Table 4.1. Broad band output noise levels produced by the 2650 with source capacitance Cs ≥ 1 nF

5. SERVICE AND REPAIR

The 2650 is designed and constructed to provide the user with many years of safe, trouble free operation. However, should a fault occur which impairs its correct function and operating safety, then it should be immediately disconnected at the mains source and be secured against unintended operation. For repair consult the separate service Instruction Manual provided, or contact your local B & K service representative. Under no circumstances should repair be attempted by persons not qualified in the service of electronic instrumentation.



Brüel & Kjær DK-2850 NÆRUM, DENMARK · Telephone: + 45 2 80 05 00 · Telex: 37316 bruka dk

Printed in Denmark by Nærum Offset