



System for very-low-level sound measurements

types 4179, 2660

Condenser Microphone and Microphone Preamplifier

FEATURES:

- Very low inherent noise floor of $-2,5\text{dB(A)}$. (-7 to -16dB in the $1/3$ octave bands 20 Hz to 20 kHz)
- High sensitivity: 1V/Pa
- 0° incidence free-field frequency response in accordance with IEC 651, Type 1
- Microphone individually calibrated
- Well-defined operating characteristics

USES:

- Hearing research
- Monitoring of very low background noise levels
- Sound power measurement of very-low-level sources
- Distanced measurement of very-low-level compressor, fan or motor noise where close measurements are impaired by wind-induced noise

Condenser Microphone Type 4179 and Microphone Preamplifier Type 2660 constitute a unique system for measuring sound pressures well below the nominal $0\text{dB re } 20\mu\text{Pa}$ reference level for acoustic measurements. The $1/3$ octave bandwidth inherent noise floor of the complete system at 1kHz is typically -16dB .

The frequency response of the combined system ranges from 7Hz to $12,5\text{kHz} +2, -3\text{dB}$ and is in accordance with IEC 651, Type 1 requirements. The high sensitivity, low inherent noise and well-defined operating characteristics of this microphone and preamplifier assembly provide a versatile system which is suited to a wide range of applications: from laboratory hearing research and quality assurance measurements in anechoic chambers to industrial measurements of very low-level machine noise.

Type 4179 is supplied with a calibration chart which includes individually measured frequency responses, sensitivity and inherent noise.

High-quality, conventional $1''$ condenser microphones such as B&K Types 4144 and 4145 typically have an inherent noise level of 10dB(A) . They provide a combined assembly noise floor of approximately 11dB(A) and thus a useful dynamic range from 14dB(A) . Half-inch diameter Types 4165 and 4166 provide similar " $1''$ performance" low-noise and high sensitivity, yet offer the wider frequency range associated with their smaller diameter. These $1''$ and $1/2''$ types adequately cover the majority of noise measurements to IEC, ISO and ANSI standards. However, with a noise floor of -5 to $+5\text{dB}$ in the $1/3$ octave bands

between 20Hz and 20kHz , measurements close to and below the $20\mu\text{Pa}$ reference pressure cannot be made, and larger diameter designs would compromise the useful frequency range and omnidirectivity of a microphone intended for precision measurements.

To facilitate measurements of ultra-low sound pressure levels, B&K has developed $1''$ Condenser Microphone Type 4179 and Microphone Preamplifier Type 2660. The noise floor of the assembly is typically $-2,5\text{dB(A)}$. With narrow band analysis this falls to approximately -16dB ($1/3$ octave band-

width at 1kHz) and -34dB ($3,16\text{Hz}$ bandwidth at 1kHz). The system is well-suited for both laboratory and industrial applications ranging from hearing research to the measurement of very-low-level machine noise.

System Description

Introduction

Type 4179, shown in Fig. 1, is delivered in a mahogany case together with an individual calibration chart. It is fitted to the Type 2660 using $1/2''$ to $1''$ Adaptor DB 0375, and space is provided in the case of the 2660 for storing





Fig. 1. Type 4179 as delivered in mahogany case

the assembly and the 4179 case. In order to protect the diaphragm from dust penetration, it is recommended that the plastic cap supplied with the 4179 is replaced when the microphone is not in use.

Fig. 2 shows a simplified block diagram of the 2660. The Preamplifier is equipped with a three-position function selector which is set to either the "Lin. 0dB" or "Lin. +20dB" position for use with condenser microphones other than Type 4179. Type 2660 accepts 1/2" microphones directly and 1"

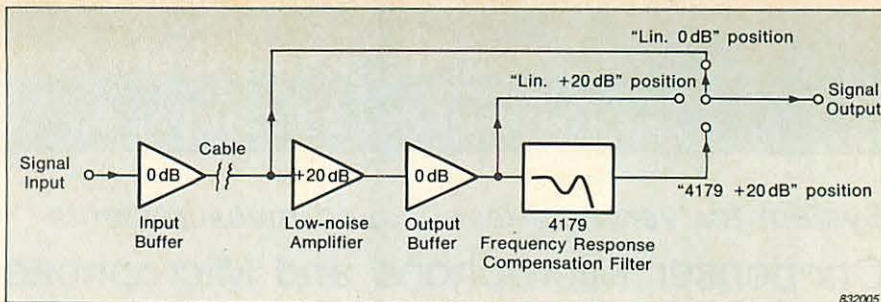


Fig. 2. Simplified block diagram of Type 2660, showing the signal path in each of the three operation modes

types via adaptor DB0375 supplied. Adaptors are available for fitting 1/4" and 1/8" diameter microphones*. In use with Type 4149 the function selector is set to the "4179 +20dB" position.

The 2660 may be connected to the 7-pin preamplifier input socket fitted to the range of B&K Frequency Analyzers and Measuring Amplifiers. The necessary preamplifier power supply voltages, heater supply and microphone polarization voltage are supplied via this socket (see Specifica-

tions). Adaptor JE0002 is supplied with the 2660 for connection to the deeper preamplifier input socket of earlier B&K instruments. Type 2660 is delivered together with accessories in a mahogany case.

Frequency Response — Individual Calibration

The very low inherent noise of Type 4179 is achieved by reducing the

* For details of use of the 2660 with microphones other than Type 4179, see separate Product Data for Microphone Preamplifiers Types 2633, 2639, 2645 and 2660

Inherent Noise of Condenser Microphone Systems

In acoustic circuits, as in electrical networks, thermal noise arises as a result of damping mechanisms, or resistances, which for an acoustic circuit result in an effective equivalent noise pressure given by the equation:

$$\bar{p}^2 = \int_{f_1}^{f_2} 4KT R df$$

where \bar{p}^2 is the mean value of the squared equivalent noise pressure, K is Boltzmann's constant, T is the absolute temperature, R is the acoustic resistance and the definite integral is evaluated over frequency limits f_1 and f_2 .

For a condenser microphone, two internal sources of noise exist: the damping resistance mechanism behind the diaphragm, R_1 , and the acoustic resistance of the pressure equalization vent, R_2 . Externally, the acoustic impedance, Z_a , loading the diaphragm on the outside, has a real part, R_a , which also produces thermal noise. A corresponding loading impedance exists at the outside of the pressure equalization vent, but the effect is very small and can be neglected. The dominant acoustic impedance, and therefore the most serious noise generator, is the impedance of the diaphragm damping system, R_1 . The inherent noise of the transducer can thus be minimized by reducing R_1 .

This approach has been adopted in the design of B&K Condenser Microphone Type 4179, resulting in a damping resistance approximately forty times lower than that of conventional 1" microphones, and a corresponding reduction in noise by 16dB. Since it is not

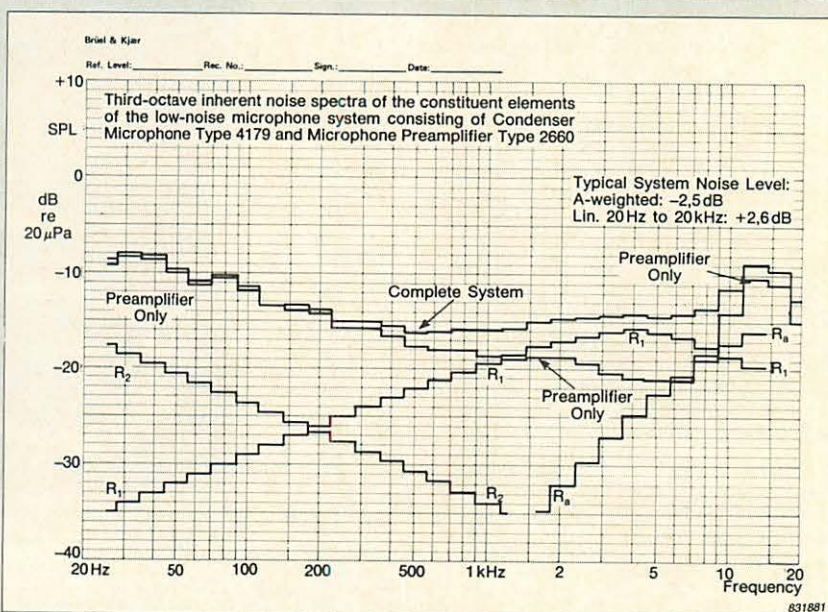


Fig. 3. 1/3 octave inherent noise spectra. Spectra for the complete system and preamplifier alone are measured. Spectra for the cartridge noise generators R_1 , R_2 and R_a have been calculated

possible to reduce the diaphragm mass and stiffness proportionally, the cartridge frequency response changes significantly; the primary resonance of the diaphragm system is underdamped and a peak appears at the diaphragm resonance of 7kHz. To compensate for this effect, a filter is built into the specially designed very-low-noise Preamplifier, Type 2660, which has been developed for use with the 4179. The frequency response for the complete system is linear within ± 2 dB from 10Hz to 10kHz.

Fig. 3 shows third-octave noise spectra of the constituent elements of the system. Spectra for the preamplifier alone and for the complete system have been measured. Spectra for the individual noise generators of the cartridge have been calculated. Owing to the large reduction in the value of R_1 , the real part of the external load impedance R_a becomes a significant noise generator at high frequencies. The inherent noise of the system is typically -2.5 dB(A).

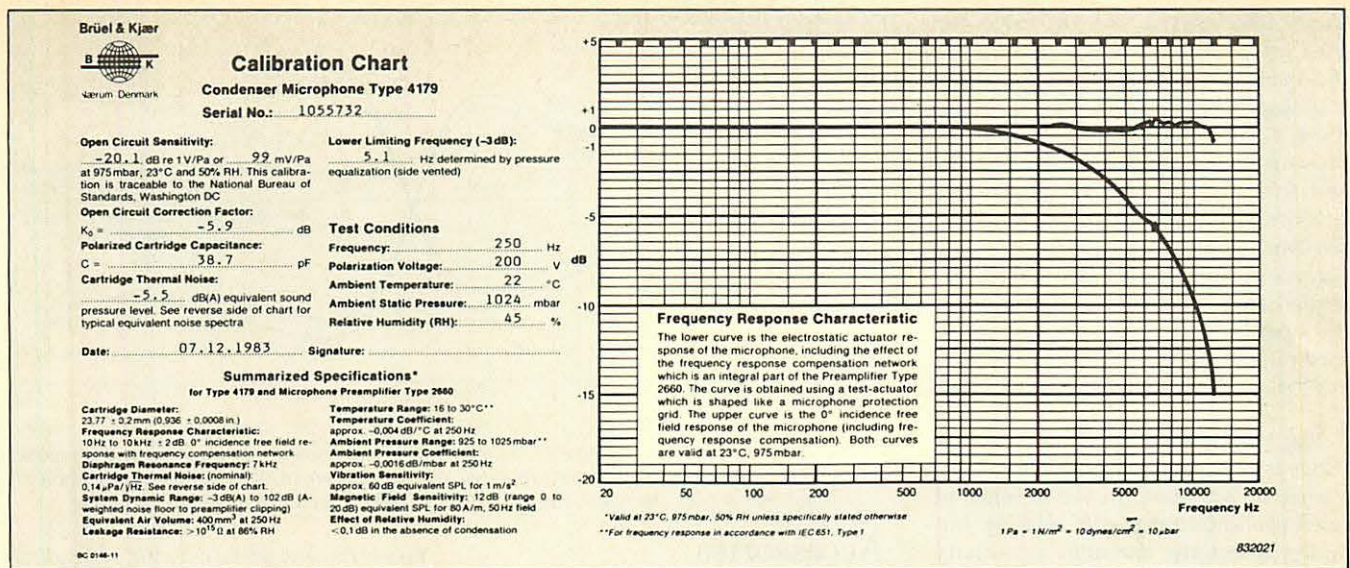


Fig.4. Calibration chart supplied with Type 4179

acoustic resistance of the diaphragm damping system. As a consequence of this reduction, the diaphragm resonance is underdamped and a peak occurs in the frequency response at approximately 7 kHz. To compensate for the resonance peak, a filter is built into Type 2660, resulting in a linear 0° incidence free-field response for the complete system which is in accordance with IEC 651, Type 1.

An example of the calibration chart for the 4179 is shown in Fig.4. The lower curve is the electrostatic actuator response. The upper curve is the 0° incidence free-field response which is obtained by adding the 0° incidence free-field correction to the actuator response. Both curves include the effect of the compensation filter built into the 2660. The calibration chart also includes individually measured values of sensitivity, inherent noise and other relevant data for the 4179.

Free-field correction curves for the 4179 are shown in Fig.5. These show the pressure increase which occurs owing to the presence of the microphone itself in the sound field. The free-field response at a specified angle of incidence can then be obtained by adding the relevant free-field correction to the actuator response.

Dynamic Range

Table 1 shows the dynamic range of the assembly. The lower limits indicate the system noise floor for different bandwidths of the associated measurement equipment, while the upper limit indicates the 3% distortion limit. Note that the lower limits for 1/3 octave and 3,16 Hz bandwidths are valid

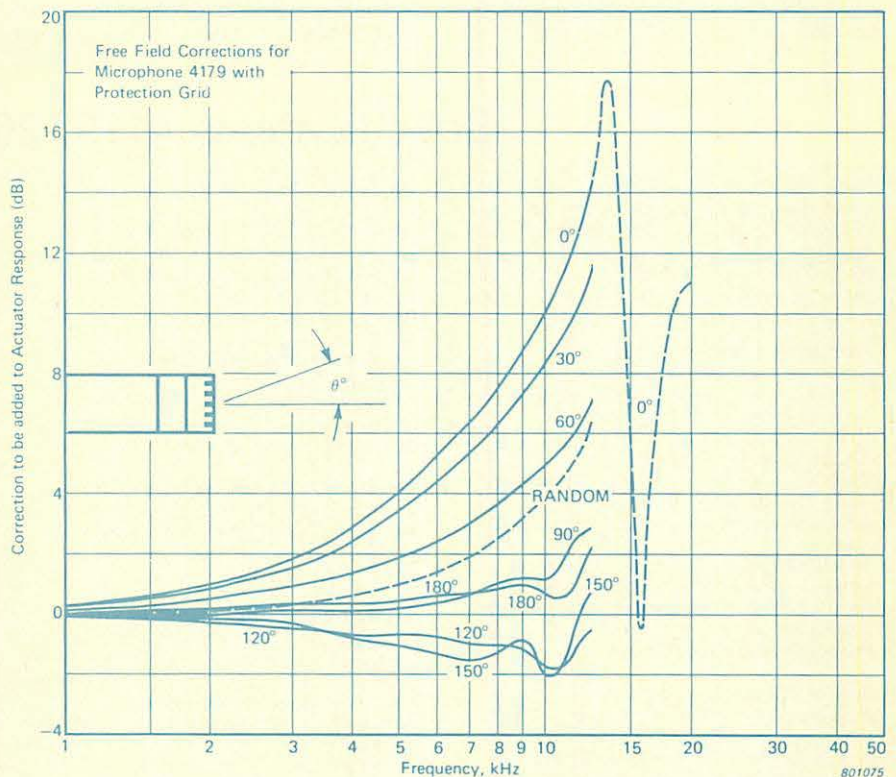


Fig.5. Free-field correction curves for Microphone Type 4179

Upper Limit	<3% distortion	102 dB
	Lin. 20 Hz to 20 kHz	+2,6 dB
Lower Limit	A-weighted Level	-2,5 dB
	1/3 octave at 1 kHz	-16 dB
	3,16 Hz at 1 kHz	-34 dB

Table 1. Dynamic range of the assembly

at 1 kHz only. Third-octave spectra are shown in Fig.3.

If the maximum output current of the preamplifier is exceeded, the sig-

nal will be distorted. In use with the 4179, the maximum input voltage of the 2660 is 0,25 V RMS which corresponds to a maximum SPL of 102 dB re 20 μPa (105 dB peak). Since the system frequency response is limited above 14 kHz, the effect of capacitive loading on the preamplifier output due to extension cables can be neglected.

Environmental Considerations

Ambient temperature or pressure variations cause a shift in the reso-

nance frequency of the cartridge and thus affect the frequency response of the combined system. For frequency response in accordance with IEC 651, Type 1 the ambient temperature and pressure ranges are from 16°C to 30°C and from 925 mbar to 1025 mbar, respectively. Fig. 6 shows the change in sensitivity for temperature or pressure variations over these ranges. With extended frequency response tolerances the operating temperature and pressure ranges are from -10°C to +50°C and from 800 mbar to 1040 mbar.

The long-term stability of the cartridge is very good, with less than 1 dB change in 250 years. In the absence of condensation changes in relative humidity affect the cartridge sensitivity by less than 0,1 dB.

The operating temperature range of the 2660 is from -20°C to +60°C.

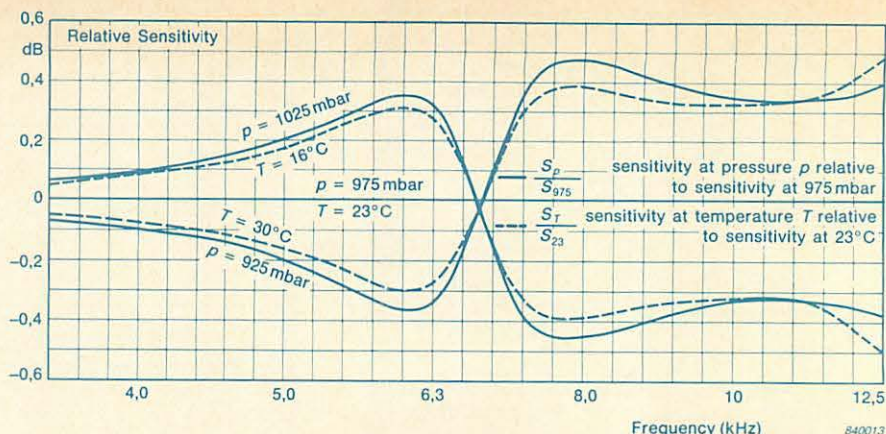


Fig. 6. Relative sensitivity of Type 4179 for variations in ambient temperature and pressure. The data given may be extrapolated to give the sensitivity change (with reduced accuracy) over the wider ranges -10°C to +50°C and 800 mbar to 1040 mbar

Accessories

An expanded foam windscreens UA 0207 is available for use outdoors or in very dusty environments. This windscreens may also be used in other

measurement situations for additional protection of the diaphragm. The effect of the windscreens on the frequency response of the microphone is small, within ± 1 dB up to 10 kHz.

Specifications 4179, 2660

Note: Data given here refer to use of the 2660 with Type 4179. For details of use with other condenser microphones, please refer to the separate Product Data available for Types 2633, 2639, 2645 and 2660. Cartridge data valid at 23°C, 975 mbar, 50% RH unless specifically stated otherwise.

FREQUENCY RESPONSE*

See Fig. 4. In accordance with IEC 651, Type 1. 0° incidence free-field response from:
 14 Hz to 4 kHz ± 1 dB**
 10 Hz to 10 kHz ± 2 dB**
 7 Hz to 12,5 kHz +2, -3 dB**

Cartridge Lower Limiting Frequency*:
 -3 dB point at 5 to 7 Hz, determined by pressure equalization system (side vented)

SENSITIVITY:

System: nominally 1 V/Pa (0 dB re 1 V/Pa)
Cartridge*: nominally 100 mV/Pa at 250 Hz (-20 dB re 1 V/Pa)
Preamplifier Gain: 20 dB ± 0,1 dB

INHERENT NOISE:

Cartridge Thermal Noise: 0,14 μPa/√Hz.
A-weighted*: -5,5 dB(A) including R_a**
 Lin. 20 Hz to 20 kHz: -3,5 dB including R_a**
Preamplifier Equivalent Input Noise:
 typically 1,1 μV A-weighted with 50 pF connected to preamplifier input
Total System Noise: See Fig. 3
 A-weighted: -2,5 dB
 Lin. 20 Hz to 20 kHz: 2,6 dB

PREAMPLIFIER INPUT:

Input Impedance: 36 GΩ || 0,3 pF
Maximum Input Voltage: 0,25 V RMS

PREAMPLIFIER OUTPUT:

Output Impedance: 50 Ω
Maximum Output Voltage: 2,5 V RMS sine (unloaded)

* Individually calibrated

Maximum Output Current: 7 mA peak

UPPER LIMIT OF DYNAMIC RANGE:

Cartridge Open Circuit Distortion Limit:
 < 3% at 100 Hz at 140 dB re 20 μPa
 Safety limit: 154 dB peak.
Upper Limit of System: 102 dB re 20 μPa

SENSITIVITY TO VIBRATION:

Cartridge: 20 mPa/ms⁻² or 60 dB equivalent SPL at 1 ms⁻². (f < 1 kHz)
Preamplifier: 400 μV or 46 dB equivalent SPL at 1 ms⁻²

SENSITIVITY TO MAGNETIC FIELDS:

Cartridge: typically 12 dB (range: 0 to 20 dB) equivalent SPL for 50 Hz, 80 A/m field
Preamplifier: 4 μV or 6 dB equivalent SPL for 50 Hz, 80 A/m field

OPERATING TEMPERATURE RANGE:

Preamplifier: -20 to +60°C (-4 to +140°F)
Cartridge: +16 to +30°C (+61 to +86°F)***
 -10 to +50°C (+14 to +122°F) with extended frequency response tolerances
Cartridge Temperature Coefficient:
 -0,004 dB/°C at 250 Hz, mean for the range -10 to +50°C

AMBIENT PRESSURE RANGE:

925 to 1025 mbar***
 800 to 1040 mbar with extended frequency response tolerances
Cartridge Ambient Pressure Coefficient:
 -0,0016 dB/mbar at 250 Hz

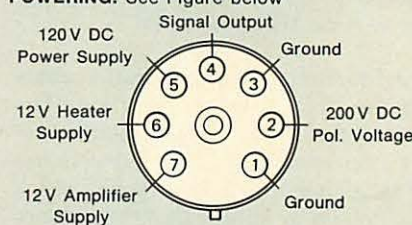
ADDITIONAL CARTRIDGE DATA:

Resonance Frequency: 7 kHz
Polarization Voltage: 200 V
Polarized Capacitance*: 40 pF at 250 Hz
Equivalent Air Volume: 400 mm³ at 250 Hz

*** with frequency response compensation network built into Type 2660

Sensitivity To Changes In Relative Humidity: < 0,1 dB in the absence of condensation
Long Term Stability: > 250 years/dB at 20°C

POWERING: See Figure below



soldering side of plug JP 0715 shown

DIMENSIONS:

Cartridge: ∅ 23,77 × 25 mm with protection grid. (∅ 23,77 × 23 mm without protection grid)
Grid and Preamplifier Mounting Threads: 23,11 - 60 UNS
Preamplifier Input Stage: ∅ 12,7 × 83 mm
Preamplifier Output Stage: ∅ 25 × 175 mm

ACCESSORIES INCLUDED TYPE 2660:

Coaxial Input Adaptor..... JJ 2617
 1/2" to 1" Adaptor..... DB 0375
 Adaptor..... JE 0002

ACCESSORIES INCLUDED TYPE 4179:

Protective Dust Cap..... DZ 9025

ACCESSORIES AVAILABLE:

Set of 6 Windscreens UA 0207..... UA 0253
 Measuring Amplifiers..... Types 2610, 2636
 Extension Cables..... AO 0027/28/29
 Tape Cable..... AR 0001

*** for system frequency response in accordance with IEC 651, Type 1