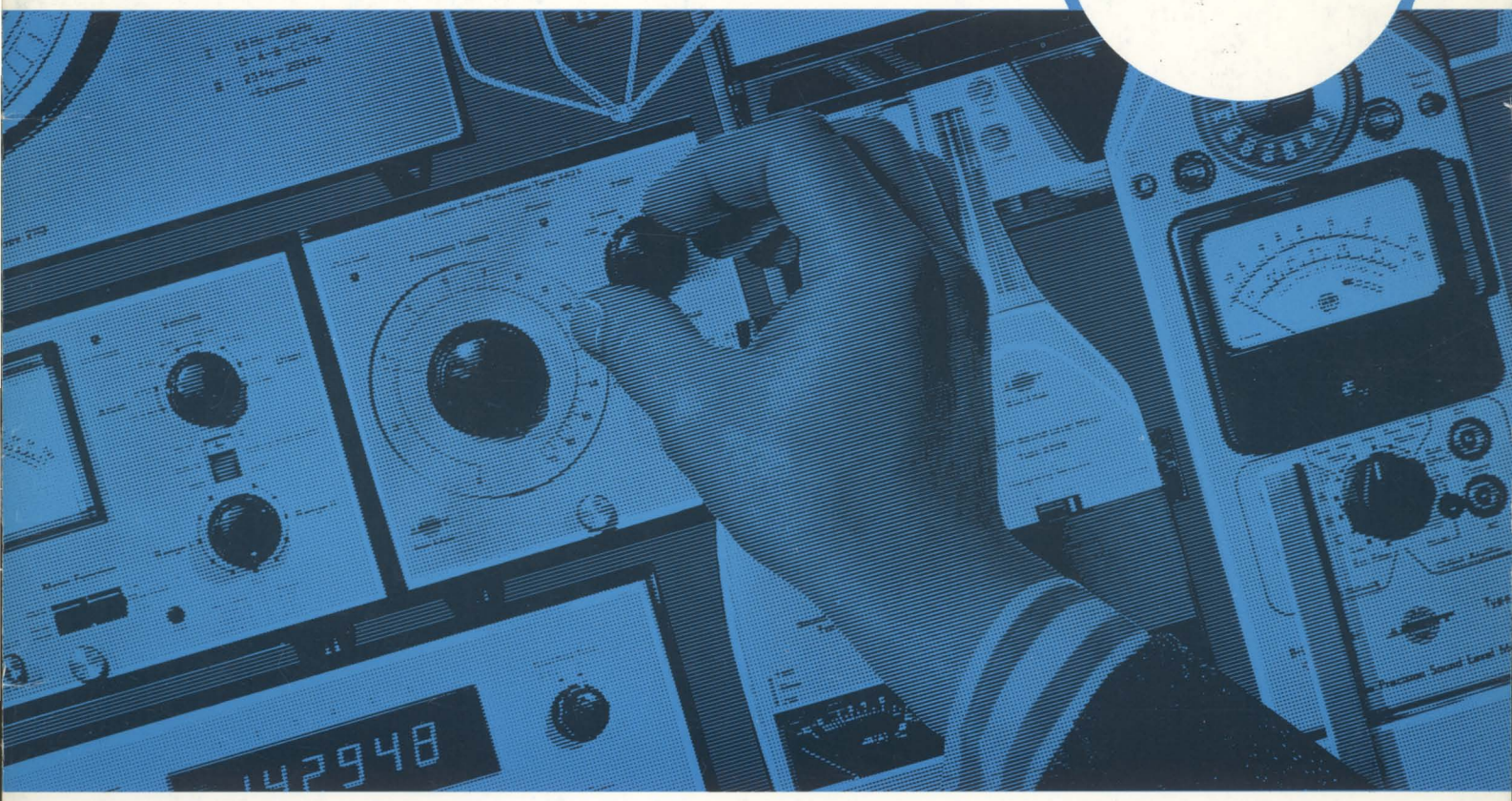
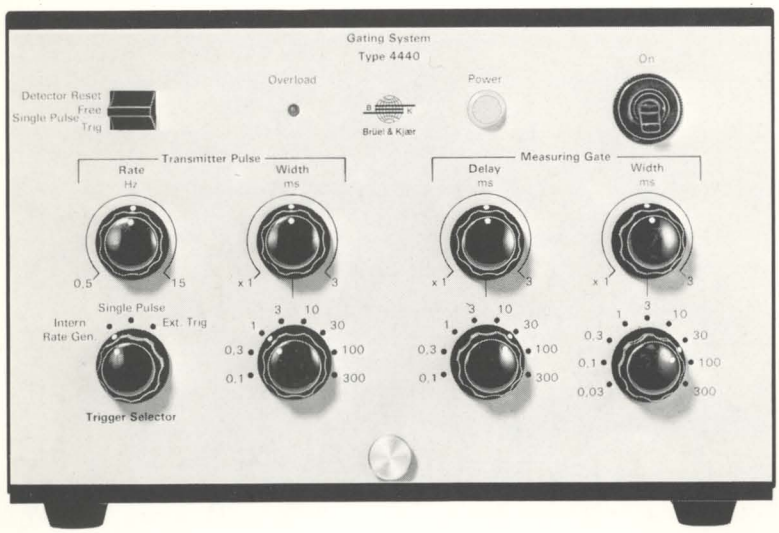
Instruction Manual 4440



Gating System Type 4440



An instrument that allows transducers to be calibrated accurately even in the presence of reflections, the 4440 cuts out the echoes caused by the boundaries of the enclosure so that free-field conditions are artificially achieved. The input continuous sine signal is gated to obtain a driving tone burst. The detector is gated and delayed to match the distance between the transmitter and the receiver, and the peak level is detected. The gate width (pulse length), tone-burst repetition frequency, and delay between the output signal and the measuring gate can all be adjusted to suit individual requirements. Apart from transducer calibrations, many other applications are possible: for example, generation of accurately-timed pulses and transients for echo investigations, absorption measurements, and medical and biological research measurements.

033-0107

Brüel & Kjær

GATING SYSTEM
TYPE 4440

Revision November 1977

CONTENTS

type 4440

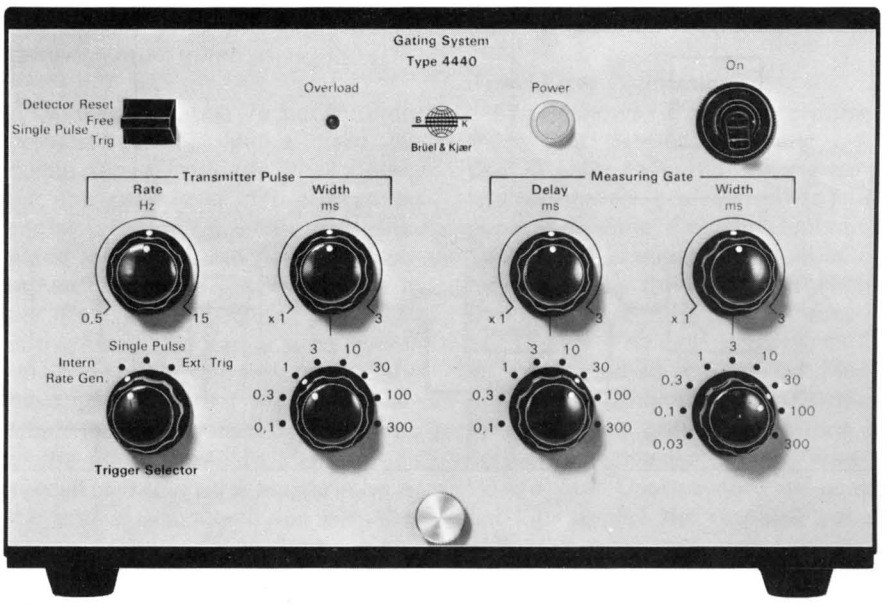
Gating System

FEATURES:

- Output tone bursts with frequency DC to 200 kHz
- Gated measurement section
- Variable burst repetition rate
- Adjustable burst length
- Adjustable delay between output gate and measuring gate
- Variable measuring gate width
- Peak detector with sample and hold
- DC and AC outputs for measurement and display
- Trigger outputs from both gate circuits

USES:

- Free field measurement in reflective environments
- Automatic recording of polar and frequency response diagrams
- Calibration of hydrophones and projectors in small bounded water tanks
- Calibration of microphones and loudspeakers
- Generation of calibrated tone bursts and transients
- Checking the performance of amplifiers, filters, detectors, and the ballistics of meters
- Research into echoes and reflection effects
- Accurate division of an input sine signal
- Generation of accurately delayed trigger impulses



The Gating System Type 4440 is the instrument that allows transducers to be calibrated accurately even when reflections are present. It is no longer necessary to calibrate hydrophones and projectors in large bodies of water, or microphones and loudspeakers in anechoic chambers to achieve free field conditions, as the 4440 eliminates the echoes caused by the boundaries of the enclosure.

Calibration is achieved by emitting an impulse from the transmitting side of the Gating System (shown schematically in Fig.1), and then measuring the received signal for only a short period during the time when the direct signal is being received. This locks out the reflected signals completely, and gives measuring results corresponding to those obtained under free field conditions.

As transducers and enclosures are available in various sizes, the frequency, length, and repetition rate of the output burst, and the position and width of the measuring gate in the 4440 can be adjusted to match a wide range of dimensions. These ranges of adjustment have been chosen to be equally suitable for calibrating hydrophones in small water tanks, and for calibration of microphones and loudspeakers.

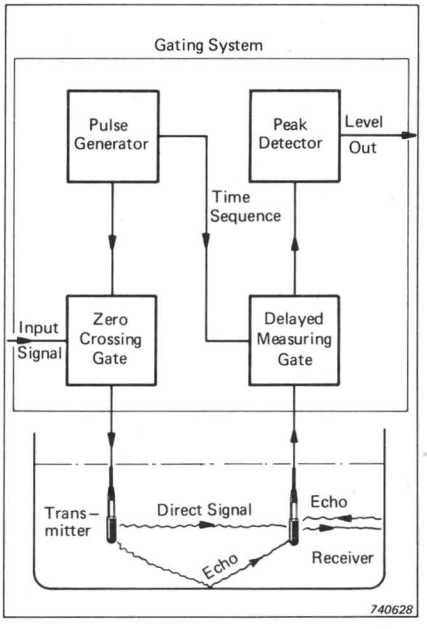


Fig.1. The basic principle of the Gating System

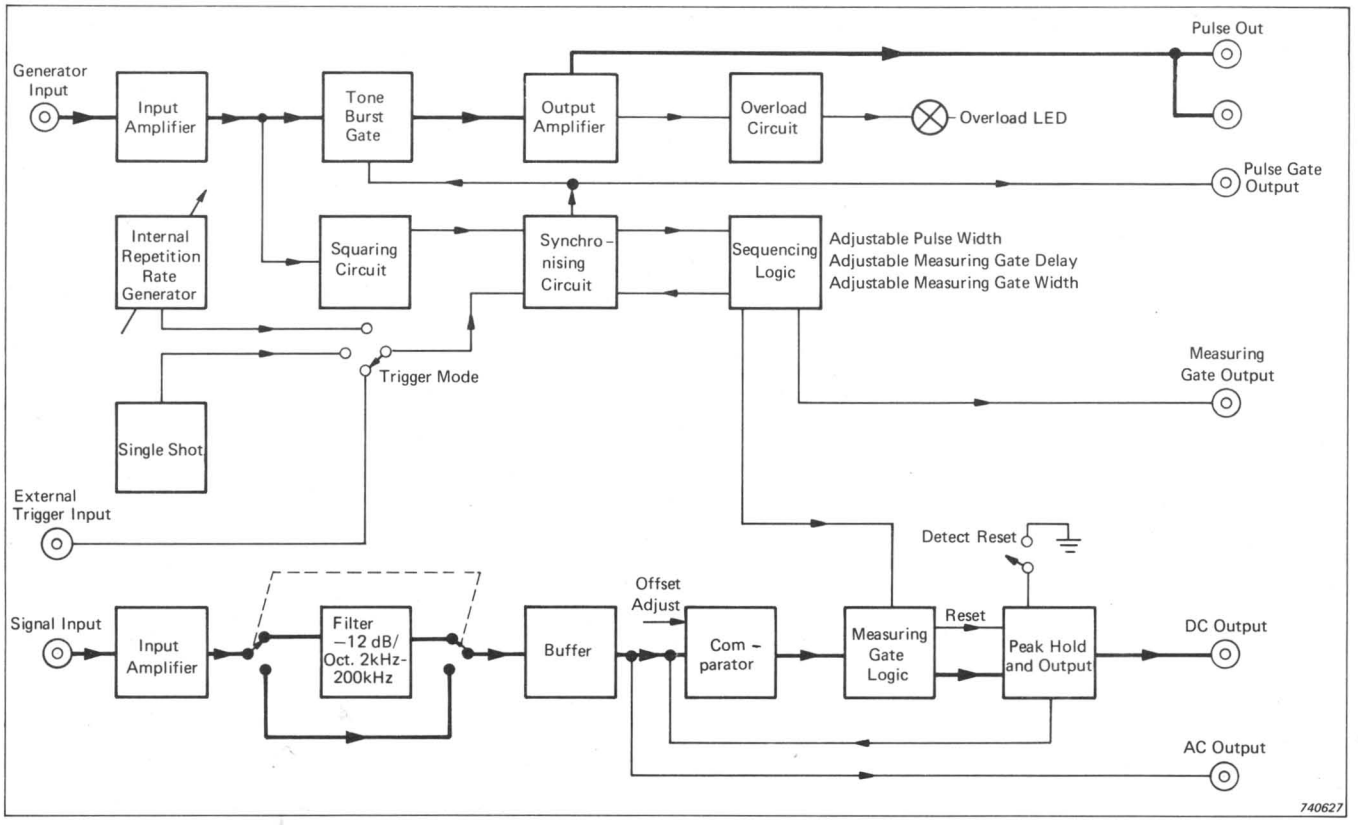


Fig.2. Block diagram of the Type 4440 Gating System

Many other applications are possible using either the transmitting or the measuring, or both sides of the instrument. These further applications include checking the performance of compressor amplifiers, measuring the bandwidth of tuned filters or amplifiers, and generation of accurately timed pulses and transients for echo investigation, absorbtion measurements, and for medical and biological research.

Description

The Gating System Type 4440 consists of a tone burst gate, and a measuring gate followed by a peak detector. A block diagram of the Gating System is shown in Fig.2.

Transmitting Section

The burst generator, consisting of Input Amplifier and MOS Tone Burst Gate, receives the signal from an external generator via GEN IN, and emits it as calibrated tone bursts via the PULSE OUT sockets.

Triggering mode is selected by a front panel knob. When "Int. Rate Gen." is selected, triggering is controlled by the Internal Repetition Rate Generator which has frequency adjustable from 0,5 to 15 Hz. This frequency range is suitable for transducer calibration in water and in air. Selection of "Single pulse" allows triggering of single pulses, released by a spring-off switch on the front panel. When "Ext. Trig." mode is selected, triggering is accomplished by an external TTL compatible source applied at the EXT. TRIG. socket. This permits remote controlled triggering, for example by a computerised calibration system.

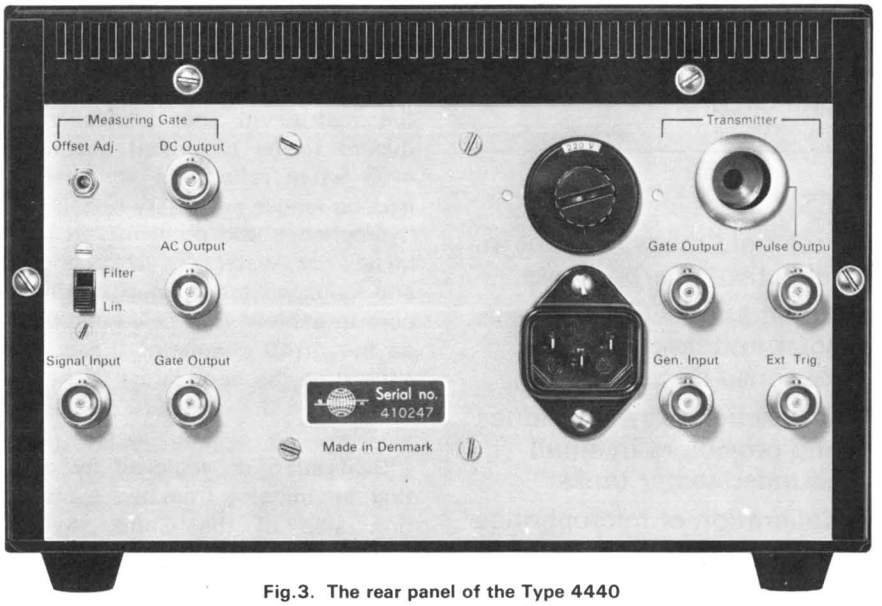


Fig.3. The rear panel of the Type 4440

The input signal is also fed via a Squaring Circuit to the Synchronising Circuit which ensures that the Tone Burst Gate opens and closes on a zero crossing point in the input signal to get a coherent burst, without transients or phase distortion. The Synchronising Circuit is the master triggering unit for all time sequencing components. It starts the pulse width timer, which is a one-shot multivibrator in the Sequen-

cing Logic, and closes the Tone Burst Gate again after receiving a return impulse from the timer. The Synchroniser is inhibited from starting another burst until all the sequences are completed. This self adjustment means, for example, that despite incorrect control settings, the repetition rate can never be made shorter than the pulse width. The total combined coarse step and fine adjustment of pulse width, allows the selection of bursts with widths between 0,1 milliseconds and 1,0 second.

Measuring Section

Similarly, the Synchronising Circuit starts timers in the Sequencing Logic that control the Measuring Gate delay, and the Measuring Gate width. These timers are also equipped with coarse and fine adjustment so that the Measuring Gate can be delayed after the start of the emitted burst for periods that are adjustable between 0,1 milliseconds and 1,0 second, while the Gate width can be varied from 0,03 milliseconds to 1,0 second.

The signal to be measured enters at the SIGNAL INPUT socket and passes to a filter that can be switched into the line for use during hydrophone calibration. It gives a slope that falls 12 dB/oct. over the frequency range 2 kHz to 200 kHz to counteract the 12 dB/oct. rise in response to voltage when a piezoelectric hydrophone is used as a projector. It also gives —12 dB/oct. from 2 kHz to attenuate low frequency noise in the system.

From the Filter, the signal passes through a Buffer into the measuring section. The Measuring Gate Logic is a control gate that only allows the peak sampling to occur during the preset "gate" interval, blocking sampling at all other times.

To obtain a fast response time, great sensitivity, and a good dynamic range from the Peak Detector, the peak level of the incoming signal is sampled, held, and compared with the held peak level obtained during the previous cycles in the burst. If the incoming peak level is the lower, the earlier held level is retained, but if the new level is the higher, the output from the Comparator increases stored level up to the higher level. In this way the voltage stored in the Hold circuit at the end of the measuring period is exactly proportional to the peak level attained while the gate was open. Further, holding the level also prevents discontinuities in the Level Recorder trace during the "off" periods in the duty cycle.

The Hold circuit is reset automatically by the internal Logic just before each measuring period. When necessary, the held level can be cleared manually by selecting "Detect Reset" on the front panel toggle switch, for example to clear the Hold circuit after a single pulse.

Examples of Use

The main application for the Gating System is for automatic recording of fixed frequency polar curves and fixed direction frequency sweeps.

Transducer Calibration

Fig.4 shows a typical arrangement that permits automatic plotting of polar calibration charts for a hydrophone (or projector). The output of the Sine Random Generator Type 1027 is gated into a series of tone bursts by the 4440 and amplified if necessary, by a Power Amplifier to give a suitable signal level. It is transmitted to a Standard Measuring Hydrophone Type 8100 that operates as a projector, emitting a series of pulses under water. Where an Oscilloscope is being used to display the received signal and to monitor the measuring gate position, the output from Transmitter GATE OUT can be used to trigger the Oscilloscope.

The receiver Hydrophone (a Type 8100 is shown) is mounted on a Turntable Type 3922 so that the polar characteristics can be charted.

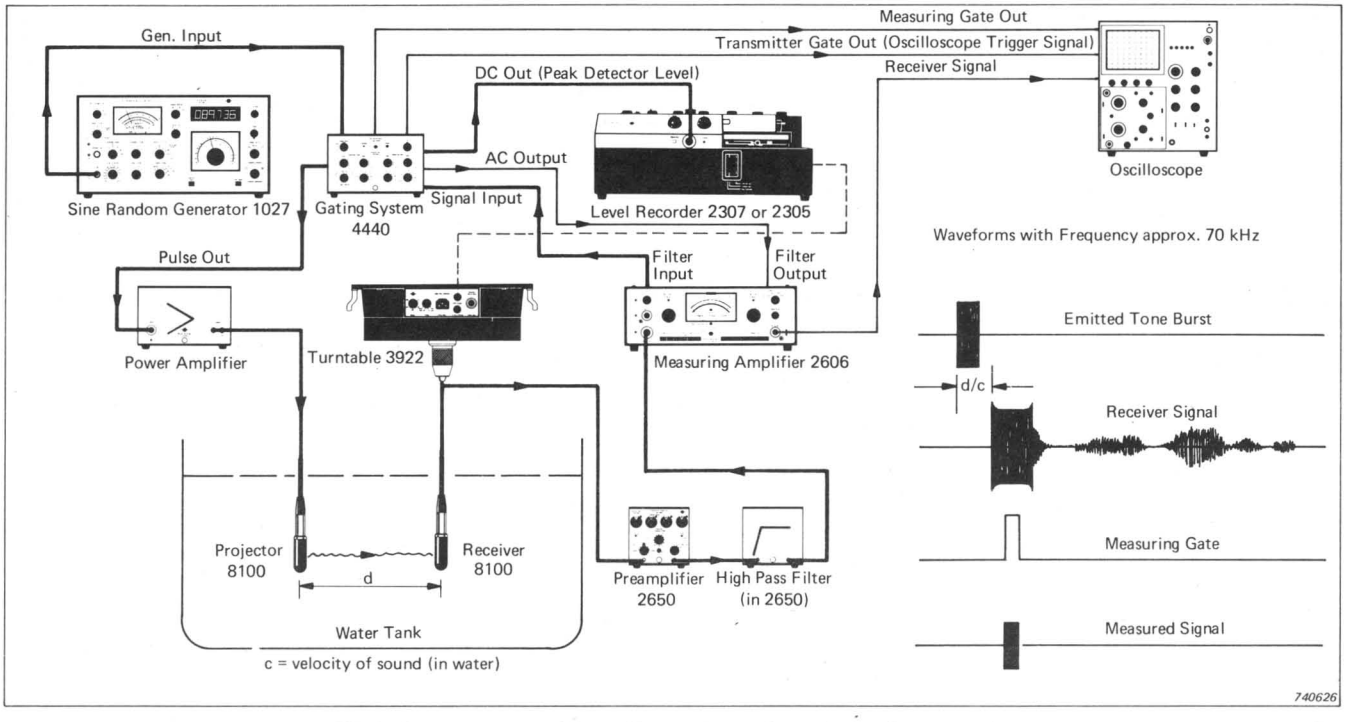


Fig.4. Arrangement used for calibrating hydrophones in small water tanks

The receiver signal is amplified, it may also be filtered to remove low frequency components, then the signal is passed to both the Oscilloscope and to the SIGNAL INPUT on the 4440.

A suitable delay is arranged to match the dimensions of the tank in use, so that the measuring gate is open only while the direct signal is being received, and shut when the reflected signals arrive. The figure also shows a typical emitted burst, the received signal complete with echoes, and the Measuring Gate signal showing the position of the measuring period.

Since the transmitting response of the Standard Hydrophone 8100 can readily be determined by performing a reciprocity calibration, the sensitivity of the unknown can be obtained from:

$$S_h = -20 \log E - S_v + 20 \log d + 20 \log e$$

where

S_h = Voltage sensitivity of unknown
E = Voltage across transmitter
S_v = Transmitting response to voltage
d = Distance between transducers
e = Voltage across receiver

Thus, by keeping E and d constant, it is only necessary to measure e.

Microphones and loudspeakers can be calibrated in air using a similar arrangement and method.

Echo Investigation

When a calibrated source and receiver are being used, the delay between the generated pulse and the measuring gate can be extended and the echoes examined to find absorbtion and reflection coefficients and the reverberation time of the enclosure. Transmission line echoes can be examined in a similar way.

Use of Tone Burst Generator alone

The tone burst generator can also be used in making the following performance checks on electronic components and circuits:

response time of detectors and compressor amplifiers,

overshoot of compressor amplifiers and the ballistics of meters,

settling time for meters, amplifiers, etc.,

rise time, and hence the band width of tuned circuits,

recovery time of compressor amplifiers,

power rating of audio amplifiers.

The zero crossing gate can also be used as an accurate frequency divider on input sine signals.

Tone bursts, and also noise bursts can be generated for use in medical and biological research into hearing, and to stimulate nerves and muscles.

Use of Measuring Gate and Delay alone

When a TTL compatible switching pulse is applied to the EXT. TRIG. socket, and a signal (such as 200 kHz) applied to GEN. INPUT to provide the zero crossing required to operate the time sequencing, the measuring gate and delay may be used alone, for example when some other burst generator is to be used.

Specifications 4440

TRANSMITTING SECTION

Input:
0,3 to 1 V RMS

Output:
15 V peak (200 mA peak current, 10 nF/200 kHz, 80 Ω)

Output Impedance:
Less than 1 Ω

Frequency Range:
DC to 200 kHz ± 0,5 dB

Pulse Gate Output:
50 Ω impedance, TTL compatible

Pulse Rate (internal rate generation):
0,5 to 15 Hz ± 10%

Pulse Duration:
100 μs to 1 s ± 10% (coarse steps and fine adjustment)

External Triggering:
DC to 200 Hz (usable up to 2 kHz), TTL compatible

Zero Crossing Accuracy:
± 1 μs at low frequencies, 10° at high frequency

MEASURING SECTION

Delay:
Initial delay = 50 μs ± 10%
100 μs to 1 s ± 10% (coarse steps and fine adjustment)

Gate Width:
30 μs to 1 s ± 10% (coarse steps and fine adjustment)

Measuring Gate Output:
50 Ω impedance TTL compatible

Gain in Linear Mode (20 Hz to 200 kHz):
0 dB ± 0,5 dB between SIG. INPUT and AC OUT
0 dB (peak) ± 0,5 dB between SIG. INPUT and DC OUT

Filter:
−12 dB/oct. between 2 kHz and 200 kHz

Dynamic Range of Amplifiers and Detector:
Greater than 50 dB

AC Output:
Maximum 10 V peak

DC Output:
Maximum + 10 V to −3 V

Detector Modes:
Repetitive: Internal or external triggering
Single Pulse: Less than ± 1 dB drift after 10 minutes Hold time (the detector is automatically reset in both modes)

Detector Free:
Hold for single pulse, with less than ± 1 dB drift in 10 minutes

Operating Temperature Range:
+ 5° to 40°C (41° to 104°F)

Power Supply:
100 to 240 V 50 to 60 Hz, approx. 10 W

Accessories Supplied:
Power Cable AN 0010

Dimensions:
Height: 132,6 mm (5,2 in)
Width: 209,5 mm (8,3 in)
Depth: 200,0 mm (7,9 in)
(KK 0025 Cabinet, 6/12 of 19" rack module)

Weight:
3 kg (6,6 lb)

2. CONTROLS

2.1. FRONT PANEL

Fig.2.1. Front panel of the Gating System Type 4440

ON: Switch for turning the instrument on and off.

POWER: Indicator lights when the power is switched on.

OVERLOAD: Light emitting diode indicating when lit that the output amplifier is overloaded.

2.1.1. Transmitter section

TRIGGER SELECTOR: 3-position switch allowing the choice of trigger mode:

"Internal Rate Gen.": this position allows the transmitter section to be triggered by the internal rate generator.

"Single Pulse": allows the transmitter section to be triggered once by depressing the toggle switch SINGLE PULSE "Trig".

"Ext. Trig": connects the rear panel BNC socket EXT. TRIG for the input of an external trigger signal.

RATE: Potentiometer which controls the rate of the internal generator from

0,5 to 15 Hz ± 10% when the TRIGGER SELECTOR switch is set to "Internal Rate Gen.".

WIDTH: Two controls to set the width of the transmitted signal:

The 8-position rotary switch gives the lower values of the 8 stepped ranges of width of the transmitted signal from 0,1 ms to 300 ms, while the potentiometer provides a continuous adjustment, multiplying the range indication by 1 to 3.

SINGLE PULSE TRIGGER: A toggle switch having two fixed and one press/release position:

"Detector Reset": resets the peak detector.

"Single Pulse Free": stand-by and hold position.

"Single Pulse Trig": for single tone burst generation only.

2.1.2. Measuring gate section

DELAY: Two controls to adjust the delay of the measuring window:

The 8-position rotary switch gives the lower values of the 8 stepped ranges of delay from 0,1 to 300 ms, while the potentiometer provides a continuous adjustment, multiplying the range indication by 1 to 3.

WIDTH: Two controls to adjust the width of measuring window:

The 9-position rotary switch gives the lower values of the 9 stepped ranges of the width of the measuring window, from 0,03 to 300 ms, while the potentiometer provides a continuous adjustment, multiplying the range indication by 1 to 3.

2.2. REAR PANEL

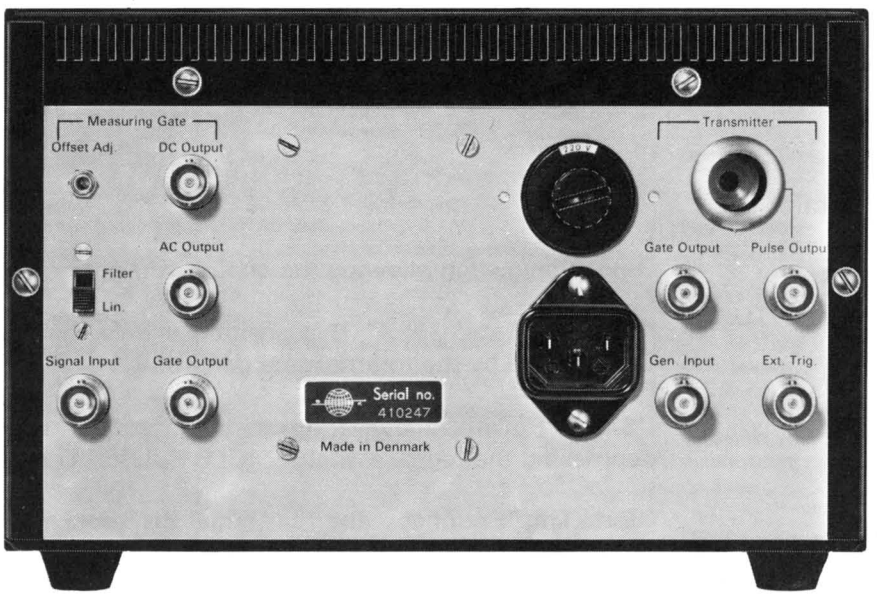


Fig.2.2. Rear panel of the Gating System Type 4440

MAINS VOLTAGE SELECTOR AND FUSE:

Voltage selector for selection of the appropriate mains voltage; the selector also contains a slow-blow mains fuse. See section 3.1.

MAINS SOCKET:

Input socket accepting the power cable AN 0010 provided for connection of an AC mains supply. Its wiring connection is shown in Fig.2.3.

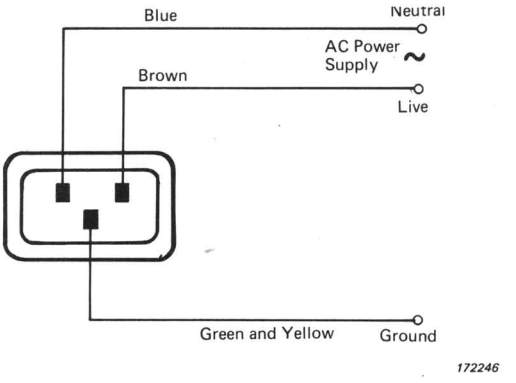


Fig.2.3. Connections to AC Power Socket

2.2.1. Transmitter section

GEN. INPUT:

A BNC socket for the input of the signal generator. Accepts the standard BNC plugs B & K No. JP 0035 or the cables AO 0064 and AO 0087 (see section 4). Input impedance: 11 kΩ.

EXT. TRIGGER:

A BNC socket for the input of the trigger signal. Input impedance: 1 kΩ, TTL compatible.

GATE OUTPUT:

A BNC socket for the output of digital information of the opening of the transmitting gate. Impedance 50 Ω, TTL compatible.

PULSE OUTPUT:

One standard B & K socket and one BNC socket, connected in parallel, for the output of the tone burst. The standard B & K socket accepts the plug JP 0101. Output impedance less than 1 Ω.

2.2.2. Measuring gate section

DC OUTPUT:

A BNC socket for the output of the continuous peak level of the signal received during the opening of the measuring window.

OFFSET ADJ.:

Multiturn potentiometer to adjust the DC offset of the DC OUTPUT from —5 to + 10 mV.

AC OUTPUT:

A BNC socket for the AC output of the signal applied to the SIGNAL INPUT, the AC OUTPUT signal being filtered or not according to the filter switch setting. Output impedance 50 Ω; should not be loaded by less than 3,3 kΩ.

Note: With the filter bypassed, there is 0 dB gain between the SIGNAL INPUT and AC OUTPUT, however there will always be a 170° phase shift between the two.

FILTER:

A 2-position slide switch with the following functions:

"Lin.": the input signal is directly fed to the AC output buffer.

"Filter": the input signal is weighted by —12 dB/octave in the 2 kHz — 200 kHz frequency range to counteract the 12 dB/octave rise in response to voltage when a piezoelectric hydrophone is used as a projector.

SIGNAL INPUT:

A BNC socket for the input of the received signal to be measured.
Input impedance: 50 kΩ.

GATE OUTPUT:

A BNC socket for the output of digital information of the opening of the measuring window. The GATE OUTPUT is TTL compatible, fan out of 10 TTL.

3. OPERATION

3.1. PRELIMINARY

3.1.1. Mounting

The 4440 can be used free-standing (cabinet type A) on its four rubber feet or in the Brüel & Kjær Rack Mounting System described in the KA, KK, KS Instruction Manual. See section 4.

The 4440 is a KK 0025 cabinet, 6/12 of 19" rack module. Its dimensions and weight are given in the specifications, chapter 1.

3.1.2. Mains Voltage Selection and Fuse

Before use, the 4440 should be checked for proper mains voltage operation. The mains voltage selector holds the fuse and allows the choice of mains voltage operation at: 100 V, 115 V, 127 V, 150 V, 220 V and 240 V, at 50 to 60 Hz. The power consumption is approximately 10 W.

To change the fuse or to select the proper mains voltage, the procedure is as follows:

Unscrew the black central knob and pull it straight out with the fuse. To select the mains voltage, pull the black voltage selector bush straight out and replace it so that the metal pin of the bush is opposite the appropriate voltage which appears in the window of the bush. Then replace the fuse and the black central knob.

The rating of the fuse is 0,2 A/250 V slow-blow type, B & K reference VF 0012.

Once the VOLTAGE SELECTOR has been set to the correct mains voltage, the mains supply may be connected to the MAINS INPUT socket using the power cable AN 0010 provided. To fit a suitable mains plug to the cable, see Fig.2.3.

The 4440 is now ready for operation since no calibration is needed.

3.2. GENERAL

The operation of the 4440 requires the use of a twin-channel oscilloscope to monitor the wave forms and adjust the respective positions of the pulse gate and measuring window. In certain instances, a 4-channel oscilloscope may be found useful. See Figs.3.1 and 3.2.

See section 4 for the references of the standard B & K cables to be used.

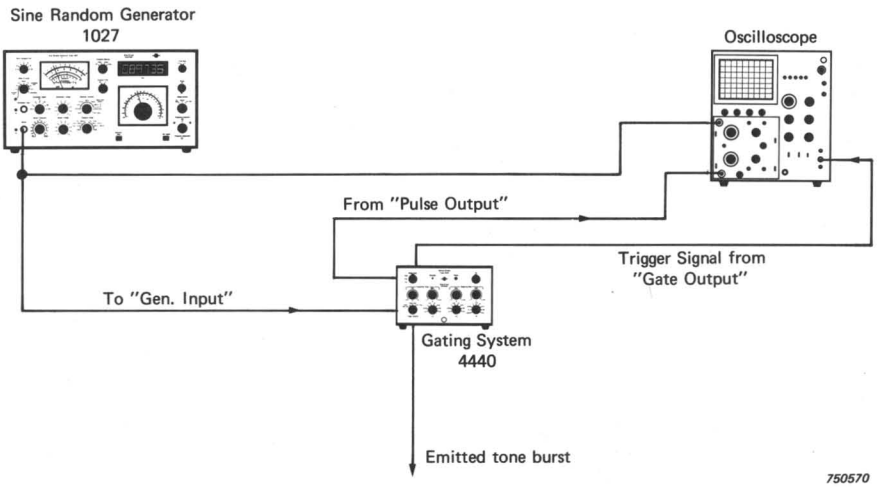


Fig.3.1. Set-up for the 4440's Transmitter Pulse Section adjustments

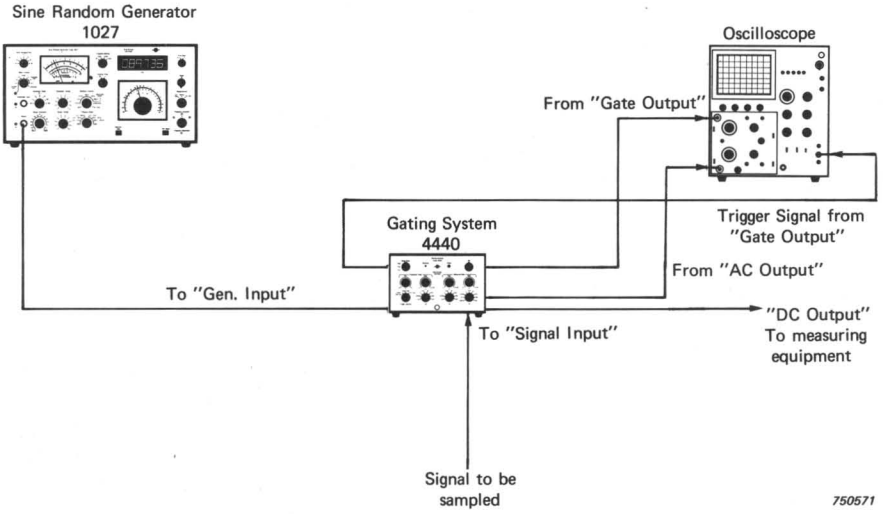


Fig.3.2. Set-up for the 4440's Measuring Section adjustments

3.2.1. Operation of the Transmitter Pulse Section

1. Switch the power on. The POWER indicator should light. Allow a few seconds for stabilisation.

2. Set the external signal source generator to the required frequency and adjust its output level to suit the 4440's GEN. INPUT level requirement, i. e. within 0,3 and 1 V RMS.

3. Connect the signal from the generator to the GEN. INPUT socket on the rear panel of the 4440.

4. To adjust this arrangement, set TRIGGER SELECTOR to "Internal Rate Gen." and RATE to "15 Hz".

5. Check that no overload occurs. If the OVERLOAD indicator is lit, monitor the input signal. An overload due to capacitive loading can be indicated without overloading the amplifier itself, i. e. the rise time of the burst draws peak current, thus trig-

gering the OVERLOAD indication. For instance, with 10 nF capacitive load, overload is indicated from approximately 100 kHz and up with an output of 14,1 V peak. The 1 V RMS input level is an indicating limit set by specifications, but the amplifier can output without distortion up to 15,5 V peak, 230 mA peak; therefore an oscilloscope is very useful for setting up and monitoring.

6. Monitor PULSE OUTPUT on the first channel of the oscilloscope and, if desired, the input signal on the second one. The oscilloscope may be synchronised in external trigger mode by the GATE OUTPUT signal, giving precise information of the tone burst length which can be measured with the oscilloscope.

7. Set the required trigger mode and trigger rate if necessary. If the external trigger mode is used, the external trigger signal should be applied to the EXT. TRIG. socket on the rear panel.

   The transmitter section of the 4440 now operates and gives a well-defined tone burst.

8. Apply the tone burst to the relevant equipment and monitor the PULSE OUTPUT to ensure that the characteristics of the tone burst still remain the same.

3.2.2. Operation of the Measuring section

1. Short circuit the SIGNAL INPUT socket and monitor the DC OUTPUT. If necessary adjust the DC offset by means of the screwdriver-operated OFFSET ADJ. potentiometer. The DC offset voltage is adjustable within —5 and + 10 mV.

2. Apply the received signal or the signal to be sampled to the SIGNAL INPUT socket and monitor it through the AC OUTPUT socket on channel 2 of the oscilloscope.

3. Monitor the GATE OUTPUT on channel 1 of the oscilloscope and make the necessary adjustments to the delay and width of the measuring window. The oscilloscope remains synchronised by the GATE OUTPUT signal of the transmitter section.

4. If necessary, move the FILTER SWITCH to "Filter", e. g. if the purpose is to calibrate a piezoelectric hydrophone to be used as a projector, in order to compensate for its 12 dB/octave rise when used as a projector.

The measuring gate now operates and provides at its DC OUTPUT socket a DC voltage proportional to the maximum value occuring when the measuring window was open. The DC voltage is held to avoid the voltage dropping to zero between pulses.

3.3. OPERATION OF THE 4440 AS A SAMPLE AND HOLD SYSTEM

The Gating System Type 4440 can be used as a sample and hold system because of the ability of its output section to detect whether the input signal is greater or lower than the DC hold level. See Fig.3.3. The hold level is compared with the input signal, and the comparator logic decides whether a positive-going or negative-going current is to be fed through the capacitor, thus allowing a positive or a negative signal to be held, corresponding to the positive or to the negative input signal which has been sampled.

For that particular operation, the delay and the width of the measuring window are adjusted to sample the required part of the input signal. The peak detector then gives a DC voltage (maximum value of + 7 V) for a sample of the positive part of the input signal, and a maximum negative value of —3 V DC for a sample of the negative part of the in-

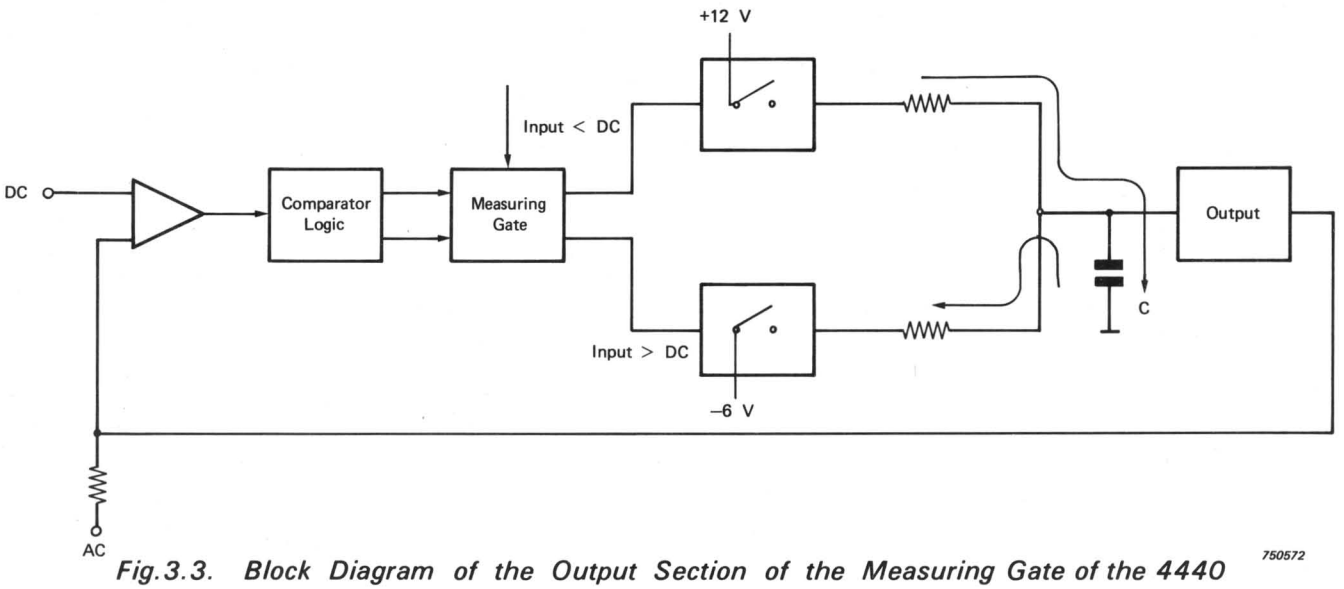


Fig.3.3. Block Diagram of the Output Section of the Measuring Gate of the 4440

put signal. This means that if the peak-to-peak value of a symmetrical signal is less than 6 V (+ 3, —3 V), every part of the signal can be sampled and held (Fig.3.4a); the same applies to a non-symmetrical signal within a peak-to-peak value of + 7, —3 V, see Fig. 3.4b. One sample remains held if the 4440 is used in the "Single Pulse" triggering mode, or in the "Ext." triggering mode, when a single trigger pulse is delivered.

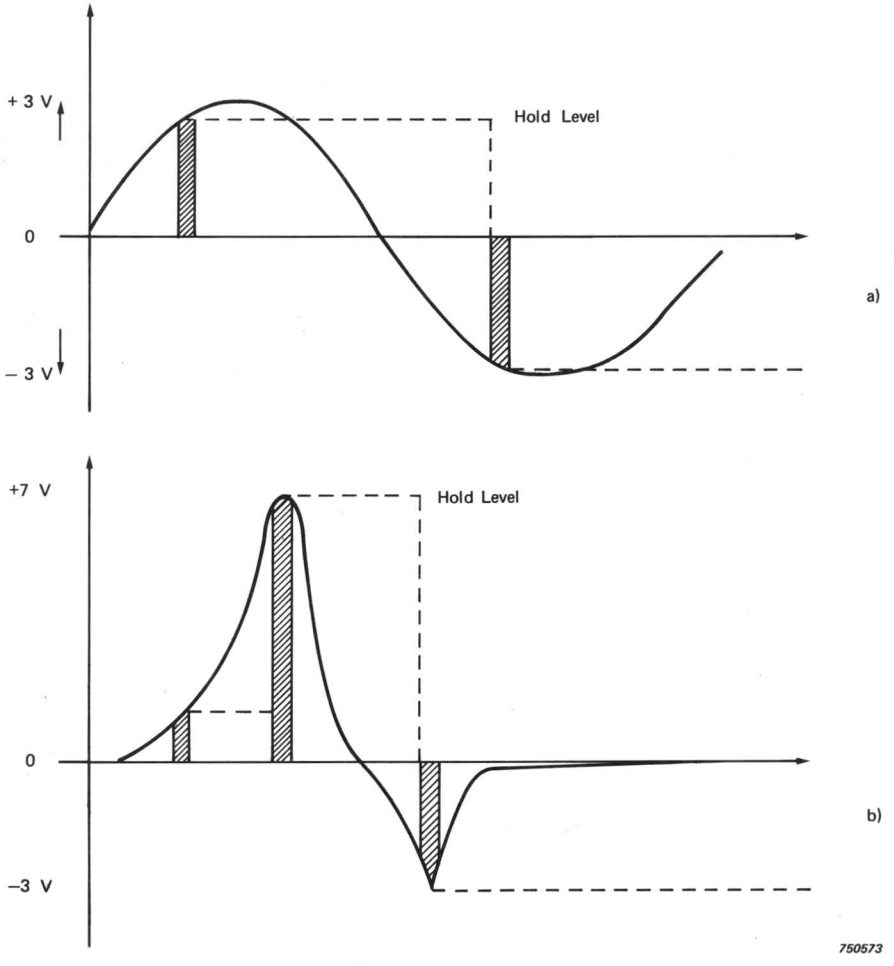


Fig.3.4. Sample and hold possibilities of the 4440

4. ACCESSORIES

4.1. CABLES

Fig.4.1 shows the cables for use with the 4440 with their respective B & K stock numbers. The plugs can be ordered separately, if required.

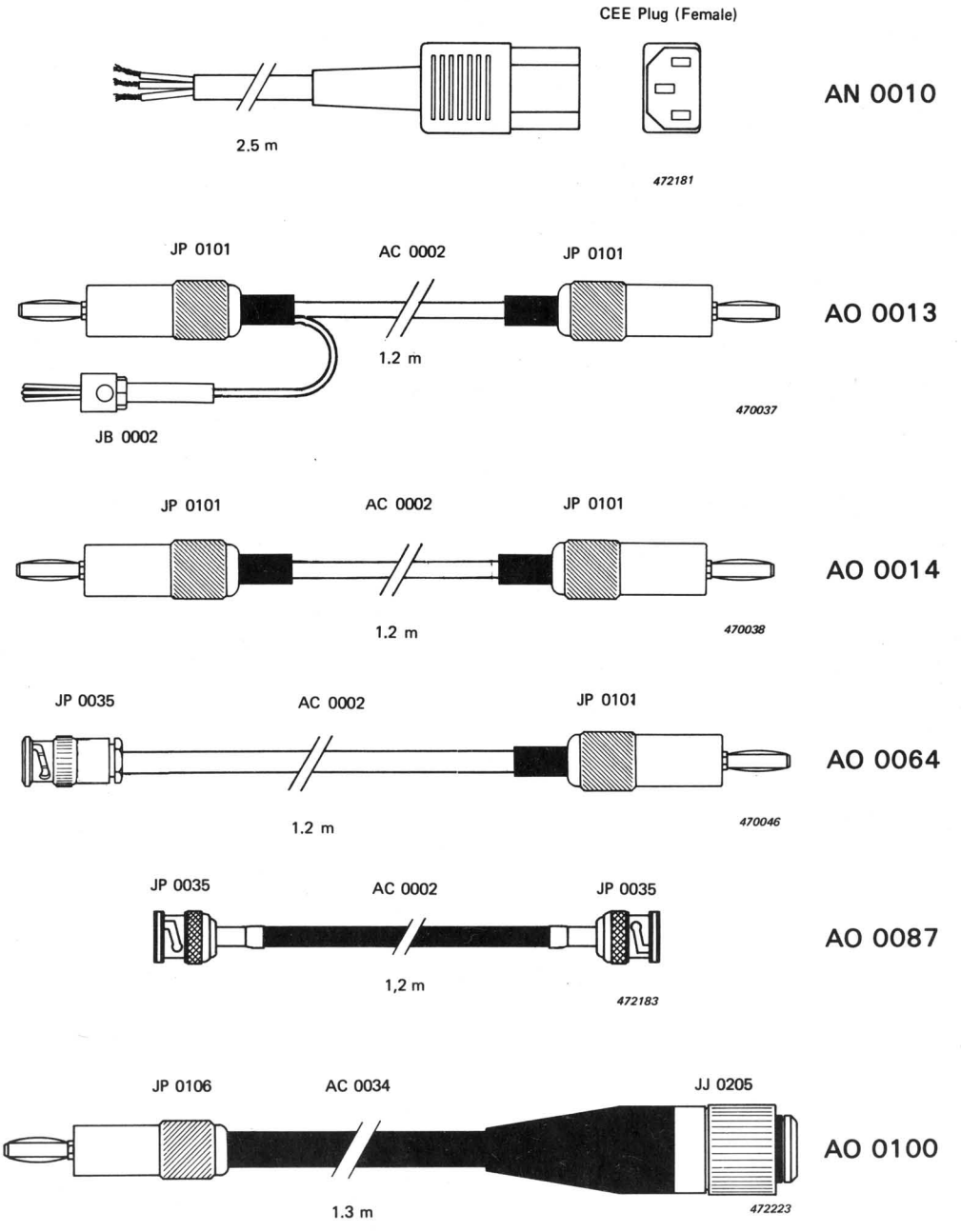


Fig.4.1. Cables for use with the 4440

4.2. RACK MOUNTING

The Gating System Type 4440 is housed in a B & K KK 0025 cabinet taking 6/12 module of the KK 0014 frame. The mounting flanges GV 1037 included in the KS 0022 mounting set enable the KK 0014 frame to be mounted in a 19 inch rack system.

4.3. MOUNTING IN MAHOGANY CASE

The 4440 being in a KK 0025 cabinet fits into a KA 0042 mahogany case if desired. It is also possible to mount the KK 0014 frame into KA 0027 mahogany case.

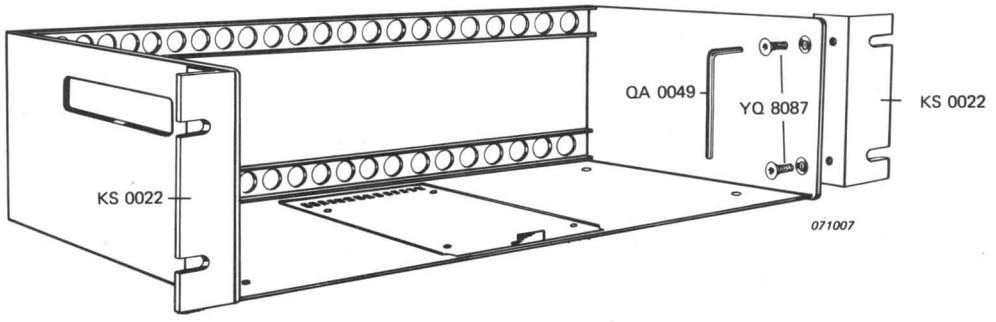


Fig.4.2. Adaptation of the KK 0014 frame to 19 inch rack system

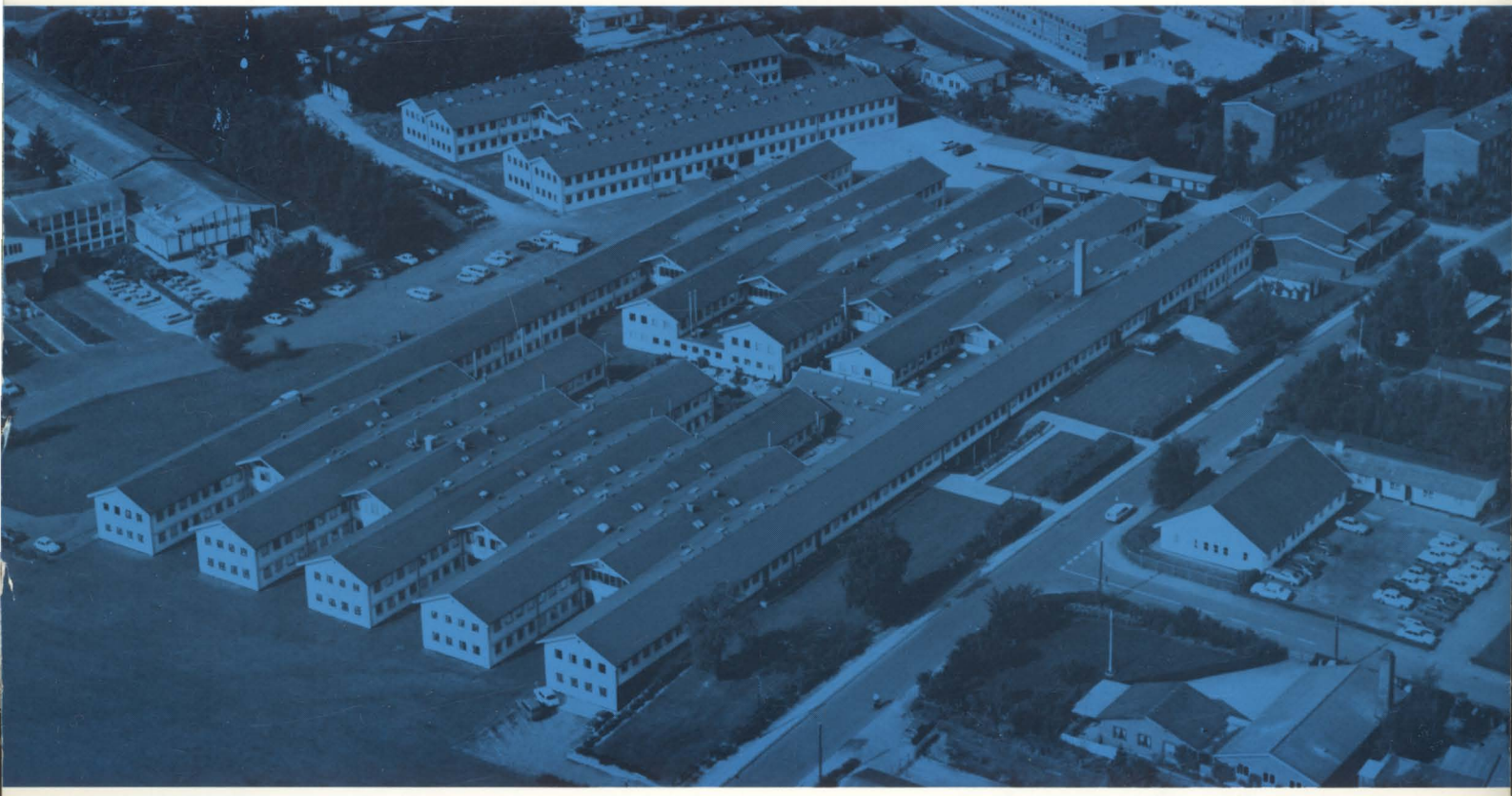
5. BIBLIOGRAPHY

5.1. HYDROPHONE CALIBRATION

Peter A. Levin: Calibration of Hydrophones. B & K Technical Review No. 1 1973. Contains a comprehensive list of references.

5.2. LOUDSPEAKER MEASUREMENTS

Henning Møller: "Electro Acoustic Free Field Measurements in Ordinary Rooms — Using Gating Techniques". B & K Application Note, May 1975.



BRÜEL & KJÆR instruments cover the whole field of sound and vibration measurements. The main groups are:

ACOUSTICAL MEASUREMENTS
Condenser Microphones
Piezoelectric Microphones
Microphone Preamplifiers
Hydrophones
Sound Level Meters
Precision Sound Level Meters
Impulse Sound Level Meters
Noise Dose Meters
Noise Level Analyzers
Standing Wave Apparatus
Calibration Equipment
Reverberation Processors
Sound Sources

ACOUSTICAL RESPONSE TESTING
Sine Generators
Random Noise Generators
Sine-Random Generators
Artificial Voices
Artificial Ears
Artificial Mastoids
Hearing Aid Test Boxes
Audiometer Calibrators
Telephone Measuring Equipment
Audio Reproduction Test Equipment
Tapping Machines
Turntables

VIBRATION MEASUREMENTS
Accelerometers
Force Transducers
Impedance Heads
Accelerometer Preamplifiers
Vibration Meters
Accelerometer Calibrators
Magnetic Transducers
Capacitive Transducers
Complex Modulus Apparatus
Bump Recorders

VIBRATION TESTING
Exciter Controls — Sine
Exciter Controls — Sine — Random
Exciter Equalizers, Random or Shock
Exciters
Power Amplifiers
Programmer Units
Stroboscopes

STRAIN MEASUREMENTS
Strain Gauge Apparatus
Multipoint Selectors

MEASUREMENT AND ANALYSIS
Voltmeters
Phase Meters
Deviation Bridges
Measuring Amplifiers
Band-Pass Filter Sets
Frequency Analyzers
Real Time Analyzers
Heterodyne Filters and Analyzers
Distortion Measuring Equipment
Psophometers
Statistical Distribution Analyzers
Tracking Filters

RECORDING
Level Recorders
Frequency Response Tracers
Tape Recorders
Alphanumeric Printers
Digital Event Recorders

DIGITAL EQUIPMENT
Computers
Tape Punchers
Tape Readers

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

PRINTED IN DENMARK K. LARSEN & SØN . 2860 SØBORG