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SOUND LEVEL CALIBRATOR
TYPE 4230

Reprint May 1974

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1. INTRODUCTION

Type 4230 is a portable, lightweight, acoustic calibrator for accurate field calibration of sound level meters and other sound measuring systems. It fits all B & K microphones of 1 inch and 1/2 inch diameter. A unique construction gives the calibrator a high equivalent volume, and the sound pressure developed is, therefore, independent of microphone volume. This means that exact fitting of the microphone in the coupler is not critical, and that different microphones can be compared without correction for equivalent volume.

The calibrator is virtually unaffected by variations in static pressure and works accurately within a wide temperature range. The sound pressure level developed is 94 dB re 2×10^{-5} Pa (1 Pa = 1 N/m^2 = 10 μbar).

The accuracy of calibration is better than ± 0.3 dB at 25°C. A frequency of 1 kHz has been chosen to give independence of the weighting networks (A, B, C and D) for sound level meters. These have a common reference of 1 kHz at which attenuation of the weighting network is zero.

2. OPERATION

2.1. GENERAL

This calibrator is made for calibration of 1 inch and 1/2 inch diameter microphones. An adaptor is placed in the front opening for use with 1/2 inch microphones, and is removed when 1 inch microphones are calibrated. (Fig.2.1).

To protect the Calibrator, store and operate it in its leather case.



Fig.2.1. Sound Level Calibrator Type 4230

The sound pressure level of the calibrator is 94 dB. However, when calibrating a microphone which is to be used for free field measurements, a small correction is necessary to compensate for the difference between free field response at 0^{o} incidence and pressure response. The correction is

−0.4 dB for 1 inch microphones (making the effective calibration level 93.6 dB) and −0.2 dB for 1/2 inch microphones (making the effective calibration level 93.8 dB). No correction is required when calibrating pressure response.

Adaptors are available so that the B & K 1/4 inch and 1/8 inch microphones can be calibrated using the 4230. The adaptor DB 0310 is required for the 1/4 inch microphone and the adaptors DB 0310 and DB 0352 are required for the 1/8 inch microphones. In each case the extra adaptors fit inside the 1/2 inch microphone adaptor supplied (DB 0311).



Fig.2.2. Calibrator Fitted on 2205 Sound Level Meter

2.2. PROCEDURE

1. Place the microphone into the coupler of the calibrator (Fig.2.2).
2. Press the button on the calibrator.
3. Adjust the measuring equipment to read according to Table 2.1.

Pressure Response		94 dB
Free Field Response	1 inch microphones	93.6 dB
	1/2 inch microphones	93.8 dB

Table 2.1. Indication required from measuring equipment for various microphone types

2.3. BATTERY CHANGE

If the signal does not last for at least a few seconds after the push-button on the calibrator has been released, then the battery needs replacing. This is done after removing the leather case by unscrewing the bottom black part of the calibrator housing (Fig.2.3), unsnapping the contacts to the battery, replacing the battery, snapping on the contacts, replacing the housing, and returning the unit to its leather case.



Fig.2.3. 9 V Battery Installed in the Calibrator

2.4. LEATHER CASE

The leather case which is included with the Type 4230 is designed to protect it and is best left on the unit except when changing batteries. The design of the case includes shock absorbing material to protect the calibrator if it is dropped. The case also protects against dust and the effects of instantaneous temperature changes, such as holding a cold instrument in a warm hand while doing a calibration.

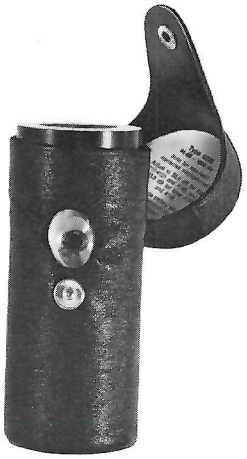


Fig.2.4. Calibrator in its leather case

3. DESCRIPTION

3.1. PRINCIPLE

The calibrator (Fig.3.1) is based on a 1 kHz stabilized oscillator which drives a piezoelectric bender. This bender is coupled to a membrane which produces a sound pressure in the coupler volume. As the system is adjusted to resonate at 1 kHz and is driven at this frequency, the equivalent volume is very high.

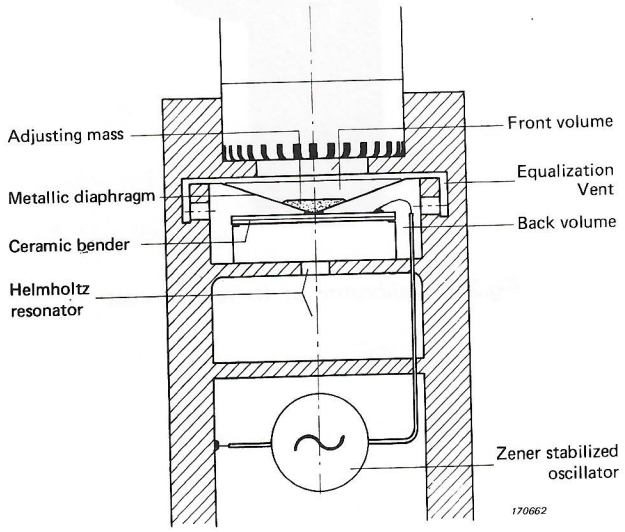


Fig.3.1. Construction of the 4230

A hold circuit is included to facilitate operation. This circuit holds the signal for up to one minute (with a new battery) after the push-button is released, thus leaving one hand free for adjustment of the sound measuring instrument. Short duration of the signal indicates inadequate battery power.

3.2. CHARACTERISTICS

3.2.1. Atmospheric Pressure

The influence of atmospheric pressure variations from the reference 1013 mbar is shown in Figs.3.2 and 3.3. Fig.3.2 shows the addition which must be made to the basic ±0.25 dB uncertainty in the calibration for pressures around and below atmospheric. Fig.3.3 shows the influence of high air pressure environments as measured on typical 4230 Calibrators.

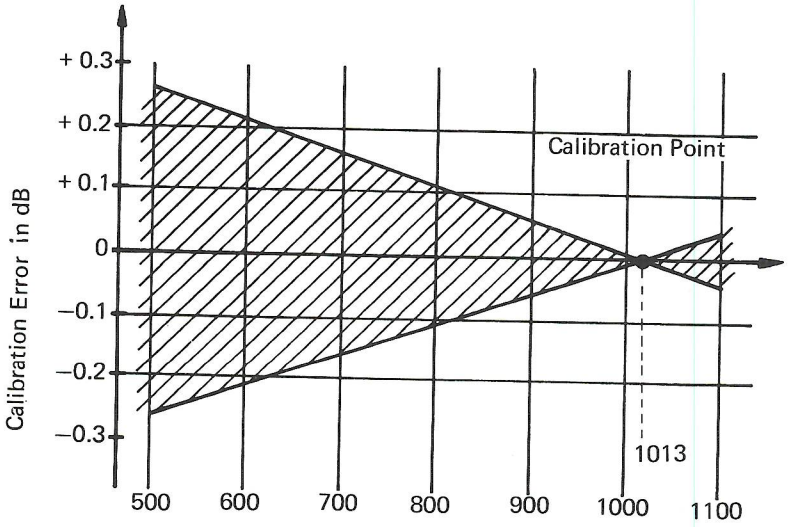


Fig.3.2. Calibration Error Caused by Variations in Atmospheric Pressure at 25°C

3.2.2. Ambient Temperature

Influence of ambient temperature on the basic ±0.25 dB uncertainty in calibration is shown in Fig.3.4.

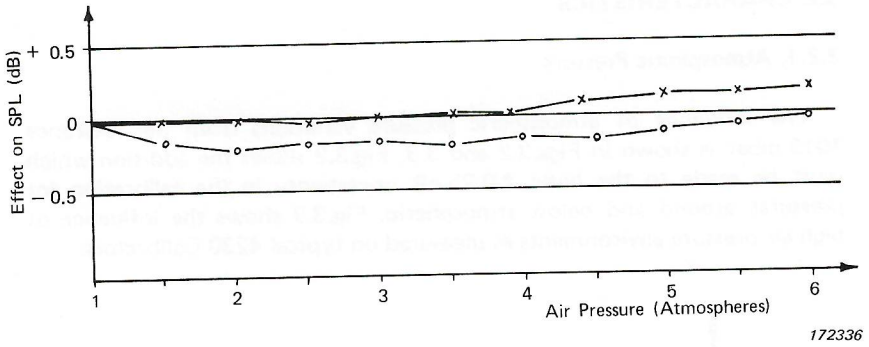


Fig.3.3. Influence of Atmospheric Pressure on SPL of Typical Sound Level Calibrators Type 4230 (1 Atmosphere = 1013 mbar)

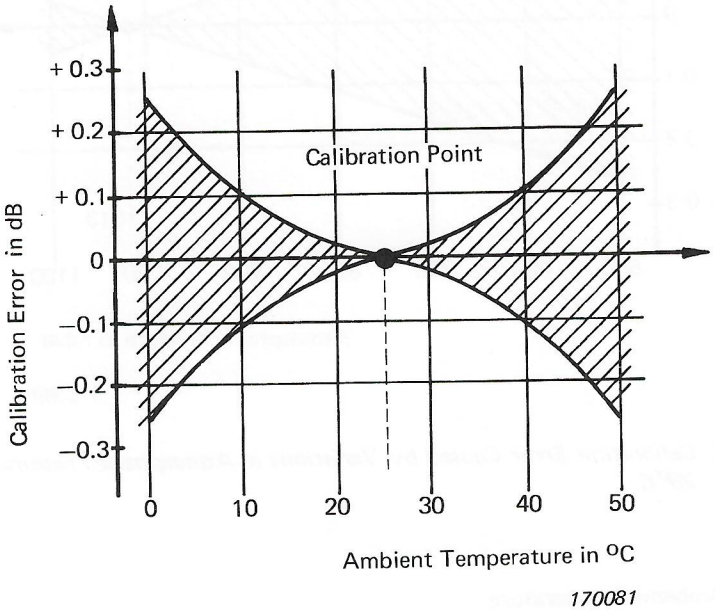


Fig.3.4. Calibration Error Caused by Variations in Temperature at 1013 mbar

3.3. DESCRIPTION AND EQUIVALENT CIRCUIT

A cross-sectional view of the Calibrator is shown in Fig.3.5. It consists of a Zener stabilized oscillator which delivers current via a potentiometer to a piezoelectric crystal. The crystal is soldered onto a metallic suspension system, which is designed so that its influence on the stiffness of the crystal is minimized. The force generated by the crystal is transformed by a conical nickel-membrane to a sound pressure in the coupler to which the microphone is subjected.

The conical part of the membrane forms a stiff piston while the plane edge of the membrane is elastic. To obtain low acoustic impedance from the point of view of the coupler volume, the moving mechanical parts of the system are adjusted to resonate at 1000 Hz which is the signal frequency of the Calibrator. Since the mass and stiffness of the membrane and crystal would give a higher resonant frequency, the frequency can be lowered by adding a mass to the membrane.

It is desirable to eliminate the cavity stiffness behind the membrane since it changes in proportion to the atmospheric pressure and would therefore influence the resonant frequency of the system. This is achieved by coupling a Helmholtz resonator (with resonant frequency 1000 Hz), giving a very low acoustic impedance at this frequency.

Finally, a pressure equalization canal between the coupler and the cavity behind the membrane is incorporated in the calibrator, to reduce the large pressure variations caused by "piston" effects, when microphones are coupled on and off, which could otherwise damage both the Calibrator and the microphones.

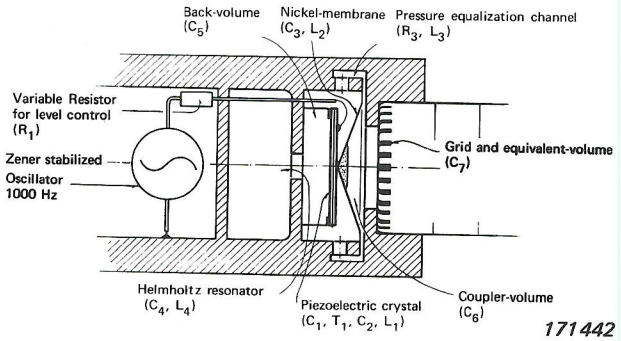


Fig.3.5. Cross-sectional View of the Calibrator

An equivalent circuit for the above mentioned elements is shown in Fig.3.6. The impedance analogy has been used, i.e. mechanical or acoustic mass is replaced by an inductance, compliance (1/stiffness) by capacitance, and damping by electrical resistance. The dimensions of the single elements are determined partly by calculation and partly by transferring the given mechanical and electrical data of the crystal to acoustical units, taking into consideration the area of the membrane through which the real acoustical elements are coupled.

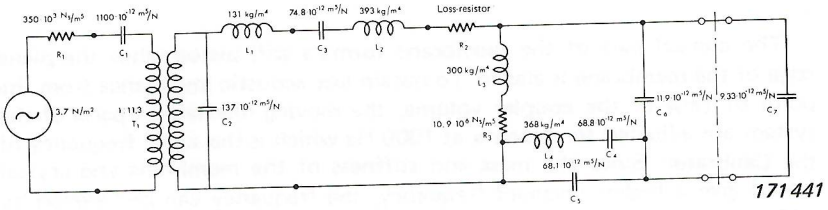


Fig.3.6. Electrical Equivalent Circuit Diagram (for 1013 mbar, 25°C)

For actual build-up of the circuit in practice, the generating side of the circuit is modified whereby the transformer can be omitted, and the impedances of the electrical elements are reduced by a factor of 10^3 to obtain the order of component impedances met in actual practice.

The simplified equivalent circuit diagram in Fig.3.7 is valid for an atmospheric pressure of 1013 mbar. Similar circuits have been built for lower atmospheric pressures during development work. These have permitted careful examination in optimising the performance of the Calibrator.

For further discussion of the equivalent circuit see B & K Technical Review 1971 No. 4, "Acoustical Calibrator Type 4230 and its Equivalent Diagram".

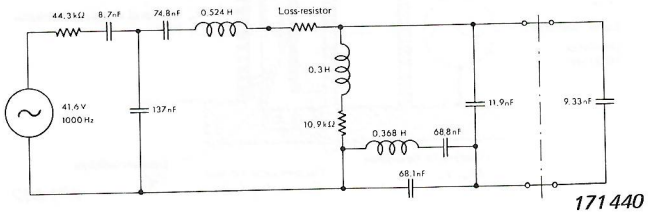


Fig.3.7. Simplified Equivalent Circuit Diagram

4. SPECIFICATIONS

Frequency:	1 kHz ± 1.5%
Sound pressure level:	94 dB re 2 x 10^{-5} Pa* 1 Pa
Accuracy (at 1013 mbar):	± 0.25 dB at 25°C ± 0.35 dB between 10°C and 40°C ± 0.50 dB between 0°C and 50°C (see Fig.3.4)
Influence of static pressure:	± 0.05 dB per 100 mbar change in pressure between 500 mbar and 1100 mbar. (see also Fig.3.2 and Fig.3.3).
Distortion:	Less than 1%
Microphone types:	1 inch and 1/2 inch
Power Supply:	Battery 1 x 9 V (IEC 6 F 22, NEDA 1604)
Battery check:	As long as calibration is possible with the button released, the change in SPL is less than 0.05 dB
Dimensions including leather case:	Length 110 mm (4.40 inch) Diameter 44 mm (1.76 inch)
Weight:	260 g. (9.2 oz)
Temperature range:	0 – 50°C

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* 1 Pa = 1 N/m^2 = 10 μbar

Equivalent volume:

$|V| > 200\ cm^3$ at 25^oC
$|V| > 100\ cm^3$ between 10^o and 40^oC
$|V| > 50\ cm^3$ between 0^o and 50^oC

Accessories Included:

1 x QB 0010	9 V Battery (IEC 6F 22)
1 x KE 0065	Leather Case
1 x DB 0311	Adaptor for 1/2 inch Microphones

Service Instructions

Sound Level Calibrator

Trouble Shooting

If any faults should occur please check the instrument according to the procedure outlined below.

When a fault has been traced and corrected the voltages and adjustments influenced by the correction must be re-checked. The complete instrument should then be tested according to the "Checking Procedure" to make sure that all basic functions are operative.

The tolerances given in these notes are intended for use as a guide for adjustments.

Before correcting any apparent deviation make sure that the measuring instrument has tolerances small enough not to affect the measurements.

Each Calibrator is individually temperature compensated. ZI 0026 is not interchangeable from one calibrator to another. The repair of a damaged membrane or the piezoelectric bender require special control equipment, and in these cases it is necessary to send the Calibrator to the factory.

Spare Parts

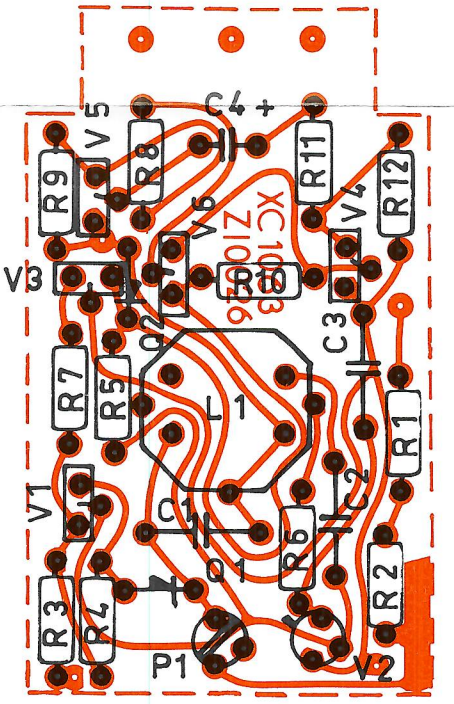
Please state the serial no. of the Calibrator when ordering spare parts.

Replacement of Parts

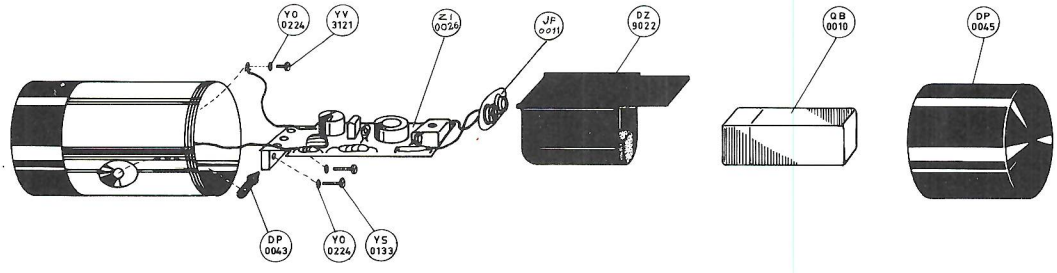
Due to the high requirement for frequency-and temperature stability only spare parts recommended by the factory should be used.

C 1	Polystyrene			0,1 µF/100 V	CS	0411
C 2	–			0,1 µF/250 V	CS	0402
C 3	–			22 µF/250 V	CS	0400
C 4	Electrolytic			100 µF/ 10 V	CE	0313
L 1	Coil			250 mH 20%	LB	0665
N 1	Switch				NT	0201
P 1	Trim. pot			200 kΩ	PG	4205
	Battery			9 V	QB	0010
Q 1	Zenerdiode	BZX 79		5 V/50 mA	QV	1339
Q 2	–	BZX 83		5,6 V/50 mA	QV	1335
R 1	Metal	1/4 W	10%	249 kΩ	RF	5249
R 2	NTC resistor		20%	15 kΩ	RN	0009
R 3	Carbon	1/4 W	5%	270 Ω	RB	2270
R 4	–	–	–	33 kΩ	RB	4330
R 5	–	–	–	470 kΩ	RB	5470
R 6	Metal	–	1%	665 Ω	RF	2665
R 7	NTC resistor		20%	15 kΩ	RN	0009
R 8	Carbon	1/4 W	5%	22 kΩ	RB	4220
R 9	–	–	–	2,7 kΩ	RB	3270
R 10	–	–	–	820 Ω	RB	2820
R 11	–	–	–	330 kΩ	RB	5330
R 12	–	–	–	68 kΩ	RB	4680
V 1	Si. transistor		NPN	BCW 82 B	VB	0055
V 2	– –		–	BC 107	VB	0032
V 3	– –		–	BCW 82 B	VB	0055
V 4	– –		PNP	BCW 62 B	VB	0049
V 5	– –		NPN	BCW 82 B	VB	0055
V 6	– –		PNP	BCW 62 B	VB	0049
	Printed Circuit Board				XC	1063
	– – –			with comp.	ZI	0026
	Leather Case				KE	0065

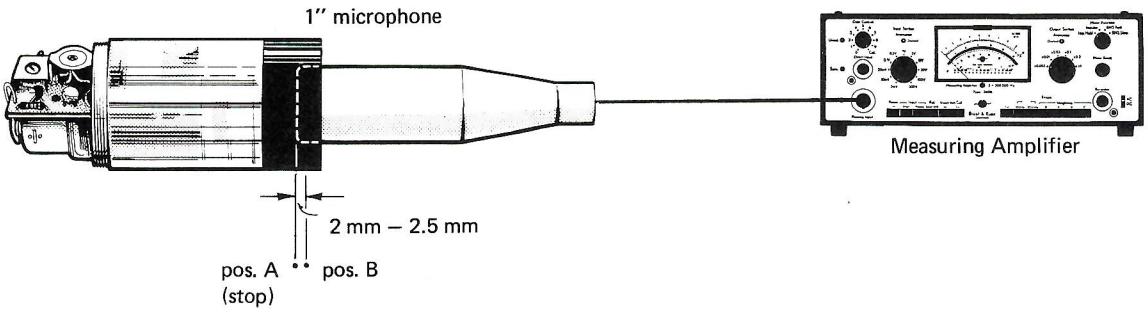
Position of Components



Exploded view



Checking Procedure



The Equivalent Volume

The equivalent volume may be checked by means of the measuring set-up shown in the figure.

a) With the microphone in pos. A the calibrator is started and the deflection of the measuring amplifier is noted.

b) Move the microphone to pos. B. The resulting change of volume (2.25 mm → $\Delta V = 1\ cm^3$) should not alter the deflection more than 0.5%.

If the change is more than 0.5% adjust the core of the coil L 1.

The Sound Pressure

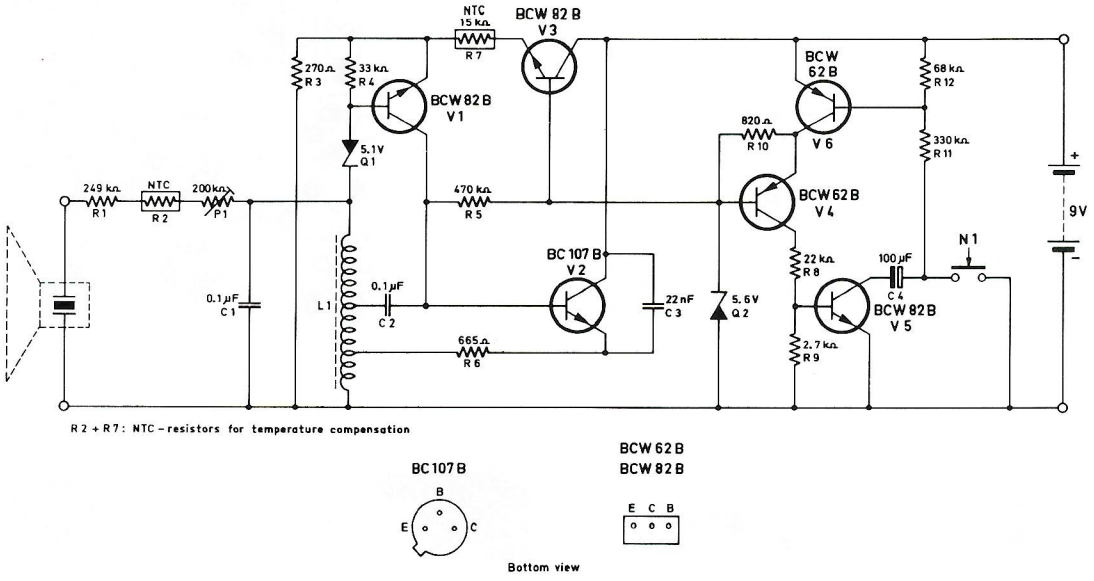
may be checked by comparison with a pistonphone Type 4220. However, attention must be paid to measuring errors that may arise because of the differences in level (124 dB and 94 dB) and frequency (250 Hz and 1000 Hz), including non-linearity in the pressure response of the microphone. Adjustment is made by alignment potentiometer P 1.

If the calibrator is adjusted to a level different from 94 dB, the temperature characteristic may change.

Adjustment should be made at a temperature between 20°C and 25°C, if the calibrator is expected to be in agreement with the B & K specifications.

For a new Battery the 1 kHz Signal should last up to approx. 1 minute. and typically 20 – 40 sec. Short duration of the signal indicates inadequate battery power.

Circuit Diagram



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