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SOUND CALIBRATOR BASED ON SILICON REFERENCE TRANSDUCER

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Summary

The paper describes a sound calibrator for measurement microphones based on feedback from a silicon reference microphone. Using feedback, the level stability is mainly determined by the stability of the internal reference microphone. Due to the high stability of the silicon microphone, the calibrator shows excellent long term stability and very low sensitivity to environmental conditions. The feedback also increases the effective volume of the calibrator.

Introduction

When we are making sound level measurements, we need to ascertain that our measurement accuracy is within the standarized requirements. A reliable sound calibrator is a valuable tool to achieve this. A sound calibrator is a device which generates a sinusoidal sound pressure of specified level and frequency when coupled to a microphone for which it is designed. The generated sound pressure should be stable and not dependent on variations in the ambient conditions such as temperature, humidity, atmospheric pressure or electromagnetic fields. Requirements to sound calibrators are described in the international standard IEC 942: 1988 and in the national standard B.S. 7189.

The use of calibrators dates back to the days when it was easier to design a stable calibrator than a stable sound level meter. Today, sound measuring instruments are stable as calibrators. However, measuring microphones are delicate devices designed to fulfill a number of requirements in addition to stability. Hence they are vulnerable and subject to damage. The modern calibrator is therefore a device to verify proper operation of the measuring instrument and for readjustment of the sensitivity.

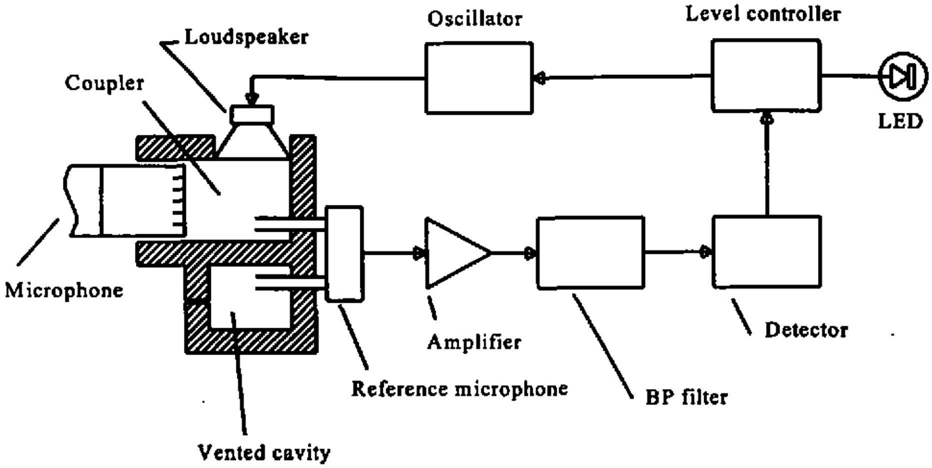

Fig. 1 Simplified block diagram of Sound Calibrator 1251

Sound Calibrator 1251

The paper describes a small, battery-powered calibrator developed by Norsonic AS; viz. the Sound Calibrator type 1251. The principle of operation is shown on the block diagram in figure 1. The microphone to be calibrated is placed in the coupler of the calibrator. The sound pressure signal in the coupler is generated by a miniature loudspeaker. The electric signal driving the loudspeaker is delivered from a stable 1000 Hz electronic oscillator whose amplitude can be controlled. A reference microphone monitors the sound pressure in the coupler and regulates the level of the oscillator until the required sound level of 114 dB (10 pascal) is reached. A light emitting diode (LED) is used to indicate proper operation of the feedback loop.

The acoustic coupler is vented to the inside of the calibrator which is again vented to the outside for equalization to the atmospheric pressure. The interior of the reference microphone is connected to a separate vented cavity to prevent pick-up of extraneous noise. Noise pick-up is also reduced by a bandpass filter in the feedback path.

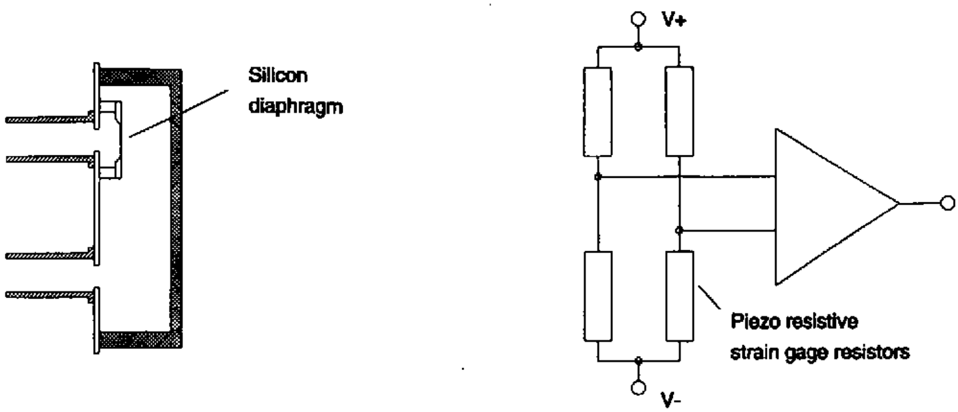

Fig. 2 Cross-section of reference microphone together with simplified circuit diagram

Reference microphone

The level stability is mainly determined by the reference microphone and the associated detector circuits. The reference microphone contains a micro-machined silicon diaphragm with four piezo-resistive strain guage resistors forming a fully active Wheatstone Bridge as shown on the figure 2.

The silicon diaphragm deflects due to the sound pressure, resulting in a corresponding electrical output voltage. The single crystal nature of silicon is a nearly ideal material for the diaphragm. The material is, within the applied limits, a fully elastic material with low dimensional creep and high stability in the diaphragm tension and corresponding high long-term stability.

For normal measuring microphones, up to 20% of the diaphragm tension is due to the compression of air behind the diaphragm. This part of the stiffness varies proportionally to the static pressure. The applied reference microphone applies high tension in the diaphragm (f_0 about 70 kHz) to obtain low sensitivity to change in the atmospheric pressure.

The silicon diaphragm has low moisture absorptionand therefore insensitive to humidity providing no condensation occurs. Due to the applied low-impedance Wheatstone Bridge principle of operation, even occasional condensation is unlikely to destroy the long term stability.

Effective volume

Various types and makes of microphones may have different effective front volumes. Due to the applied feedback principle in the Sound Calibrator 1251, the coupler has an effective volume, 50 to 100 times greater than the volume given by the dimensions of the coupler. The variations in sound pressure due to the variations in the equivalent volume for the microphone is therefore, for most applications, of little importance.

The effective volume is a measure of the dependency between the sound pressure level generated in the coupler as a function of different load volumes. If the combined effective volume and microphone load volume is V_0, a change ΔV in this volume will generate a level shift ΔL given by:

$$\Delta L = 20 \log_{10}\left(\frac{V_0}{V_0 + \Delta V}\right)$$

Due to the high stability of the silicon sensor and the electronic controller, the acoustic signal generated is virtually independent of battery voltage and ambient conditions as temperature, humidity and atmospheric pressure. The feedback principle automatically compensates for variation in the equivalent volume of the microphones, and thus creates an effective coupler volume many times the volume given by the mechanical dimensions of the coupler. The system also compensates for drift in the transducer.

Reference

IEC 942 :1988 Sound Calibrators
B.S. 7189 :1989 Sound Calibrators