APPLICATION OF EL DIRECTIONAL MICROPHONES

This note is specifically intended as instruction for use of EL Series directional microphones. Knowles offers other uni-directional and bi-directional microphones that are used differently. See Knowles Application Note AN-4 for general notes on directional microphones.

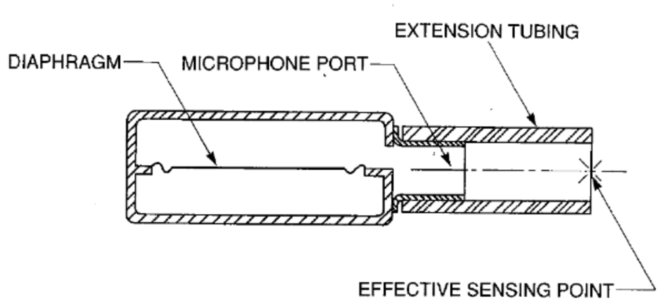
DEFINITIONS AND CONCEPTS

A certain precision in the use of key terms is necessary for understanding this application note. Since some of these terms have been used in different places with other intended meanings, we will try to accurately describe nomenclature at the onset.

A single-port microphone is able to sense instantaneous air pressure at the port opening and will produce an electrical output voltage signal corresponding to the input instantaneous air pressure signal. This type of microphone is referred to as a pressure microphone in this note, and is shown in cross-section in Figure 1. The instantaneous air pressure can be considered to be sensed at a point in the middle of the opening of the sound port, and cannot ascribe any directional quality to the input signal.

Most Knowles electret microphones have short tubular sound ports which are designed to be fitted with soft rubber or vinyl extension tubing. The extension tubing is acoustically sealed to the microphone, usually by use of a frictional fit or by use of cements. The extension tubing provides a pathway for desired sounds from the outside to reach the microphone and, at the same time, it isolates the microphone from sounds originating inside the housing. The extension tubing may be part of a microphone suspension system which isolates the microphone from housing vibration and protects the microphone from mechanical shock. One of the most important functions of the extension tubing is to allow the designer to have flexibility in the selection of locations for sound inlets thru the housing wall.

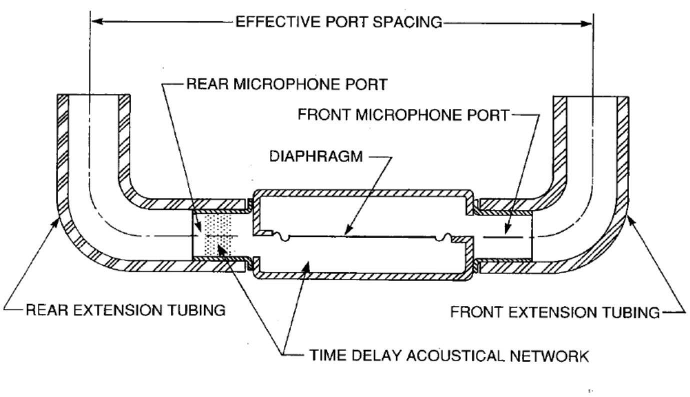
Figure 2: Pressure type microphone cross-sectional view



A directional microphone has two sound ports, each leading to a separate cavity, and the two cavities are separated by a thin diaphragm. The diaphragm senses the difference between the instantaneous air pressures which impinge on its two surfaces. This difference is transduced to give an electrical output signal. If the instantaneous air pressure in both cavities is the same magnitude and phase, the pressures acting on the diaphragm will cancel, so there will be no electrical output.

Figure 2 shows a two-port microphone with front and rear acoustic cavities, and with a time delay acoustical network at the rear acoustic port. This type of microphone will function as a directional microphone when equipped with the proper front and rear extension tubing if the ends of the extension tubes are properly spaced. With the ends of the tubing at the correct distance apart, a sound wave passing from the rear extension tubing port to the front extension tubing port through the outside air takes the same time interval as does the induced sound wave in the rear extension tubing to travel through the time delay acoustical network into the rear acoustic cavity. The distance between these extension tubing ports will determine the external time interval for the sound wave to travel between these ports. The model specification for the microphone lists the internal time delay in microseconds. This time delay varies inversely with barometric pressure and consequently, the effect of both elevation and ambient barometric pressure changes can be noticeable. The normal daily weather pressure variations can cause sufficient changes in microphone directionality to shift the location and depth of deep nulls in the polar response pattern. Therefore, striving for performance based upon deep nulls would not be conservative design practice. At a fixed barometric pressure, a 50°F (28°C) change in temperature will have approximately the same effect as a 10% change in barometric pressure. Both represent extremes that can be expected at a given altitude.

Figure 2: Directional microphone cross-sectional view



There are• four major performance parameters which are a function of the microphone system selection process, and which are interdependent:

- Sensitivity Level
- Shape of the Frequency Response.
- Polar Response Pattern
- Signal-to-Noise Performance

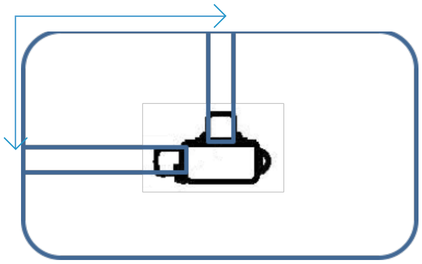
MICROPHONE SYSTEM SELECTION PROCESS INCLUDES DETERMINING:

- Microphone model number
- Front and rear extension tubing dimensions
- Location and shape of microphone apertures in housing

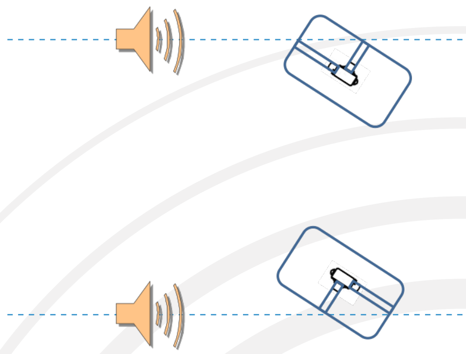
EL MICROPHONE MODEL NUMBERS (RECOMMENDED) ARE

- EL-23077-C36
- EL-23078-000
- EL-23083-C37
- EL-23085-C28
- EL-29924-C36

Knowles offers several different combinations of front and rear microphone sound port locations in standard production models. The selection of specific model directional microphones usually is based upon ease of assembly or of the best utilization of space. Once the potential model numbers have been selected, the designer should consult the appropriate Knowles specification prints for each of these models, consisting of the Outline Drawing (Sheet 1.1) and the Performance Specification Print (Sheet 2.1).

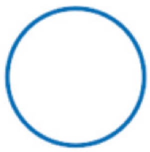


Extension tubing connects the microphone ports to the exterior housing. For purposes of the directional performance, the effective spacing of the sound ports follows the shortest distance between the ports along the contour of the housing. This distance is called the "string length", referring to the length for a piece of string reaching along the housing from the end of the front port extension tube to the rear port extension tube. For the directional pattern, 0 degree incidence occurs when the front port and rear port align with the sound source, and 180 degree incidence when aligned with rear port closest to the source.



EL-23078-000 has an internal time delay of nominally 56.8 microseconds, an RC product resulting from the selection of the acoustic damper (acoustic resistor) in the rear port. For complete cancellation at 180 degree incidence, the string length (external delay) is the product of the speed of sound (344,000 mm/sec) and the internal delay. 344.000 mm/sec x 56.8 microseconds = 19.5 mm

This condition results in a cardioid polar pattern.

	Omni	Cardioid	Supercardioid	Hypercardioid	Figure-8
Polar Pattern					
Delay Ratio, K	0	0.5	0.63	0.75	1.0
Null Angle(s)	--	180°	± 125°	± 110°	±90°
Directivity Index, DI	0 dB	4.8 dB	5.7 dB	6.0 dB	4.8 dB

If the external delay becomes larger than the internal delay, the polar pattern will begin to form a lobe in the 180 degree direction. As the ratio increases, the rear lobe will become larger. If the internal delay becomes very small compared to the external delay, the figure 8 polar pattern will result.

If the internal delay becomes larger than the external delay, there will be only partial cancellation at 180 degree incidence. If the internal delay becomes much larger, that means the rear port resistance is increasing. If the rear port resistance becomes infinite, the microphone becomes omni-directional.

For a full discussion of polar patterns, refer to Application Note AN-14.

The shape of the polar pattern describes the cancellation of incident sound waves. The Directivity Index for the polar pattern is a calculation of the attenuation of reverberant sound relative to sound originating at 0 degree incidence. Maximum cancellation of reverberant sound occurs for the Hyper-cardioid polar pattern.

Contact Knowles Field Application Engineering for assistance with microphone selection and implementation.

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Model/Reference Number:
TECHNICAL BULLETIN TB-21