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The Effect of the Singer's Head on Vocalist Microphones

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ABSTRACT

Vocalist microphones are often optimised for theoretically perfect polar patterns, e.g. cardioid, supercardioid or hypercardioid. The polar pattern can be maintained very well if the microphone is placed in the free-field, with no obstacle around it. When the singer approaches the microphone, the head serves as a reflective and diffractive obstacle. Consequently, the far-field polar patterns and frequency responses are distorted, making the microphones more prone to feedback in live amplification situations, and altering the sound of the "spill" in pure recording situations.

1. INTRODUCTION

A known effect in live amplification applications is that the acoustic feedback limit is changed by altering the sound field surrounding a microphone. This happens e.g. when the rear sound entry ports in a directional microphone capsule are closed off by the singer's hand, effectively turning the microphone into an almost omnidirectional transducer. Another effect is the actual singer and his head affecting the sound field, through reflection and diffraction at his head and body. The influence of the head is examined in the following.
"Spill" is the musicians and sound recording engineers term for unwanted off-axis sounds from other instruments, the P.A. system, or the audience reaching the microphone. One aim is to reduce the spill as much as possible, which can be achieved by making the microphone as directive as possible. Another, more pragmatic aim is to have the unavoidable spill at least be as sonically uncoloured as possible. In this way the effect of a loud instrument on stage being picked up by the vocalist's microphone will only produce a level difference but not a difference in timbre, which would be much more difficult for the sound engineer to filter out. In practice, this means for the developer that the frequency response curves of microphones for different angles of sound incidence should be as parallel to each other as possible.

The reason for this effect seems to be clear: the head is a reflective and diffractive obstacle of important size for the sound waves. Interestingly, not much seems to have been published regarding this effect [2,4].

2. THEORY, MEASUREMENTS & RESULTS

2.1. Theoretical Background

The theoretical effect of a rigid sphere on the sound field has been calculated and described by [5]. On the surface of the sphere, we obtain pressure increase for frontal sound incidence, smoothly rising with the frequency, until we reach pressure doubling at very high frequencies for which the sphere already signifies an obstacle of infinite dimensions, as used in boundary layer microphones (also called pressure zone microphones). This smoothly rising frequency response has been utilized since the 1920s for measurement microphones [1], and since the 1950s for studio condenser microphones [3]. For lateral sound, the directivity of a spherical microphone increases smoothly, so as to obtain a flat diffuse field response. For rear incidence, we obtain a relevant rear sensitivity lobe ("white spot" as it is called in optics). The aforementioned is valid for microphone diaphragms embedded in spherical housings, i.e. with the microphone sensing the pressure on the surface of the sphere.

At a small distance to the sphere, signifying the case of a microphone in the vicinity of a spherical obstacle, the situation changes. We have two components in the sound field: the direct sound wave, diffracted around the sphere depending on the angle of sound incidence, and sound waves reflected by the sphere. The rather complicated calculations for this case are given in [5]. Essentially, we obtain an additional frequency dependent behaviour, as a function of the distance between microphone and sphere. This case is depicted in figure 1, where a small omnidirectional microphone was placed at close distance to a dummy head, and measured in an anechoic chamber, with the results shown in figure 2.

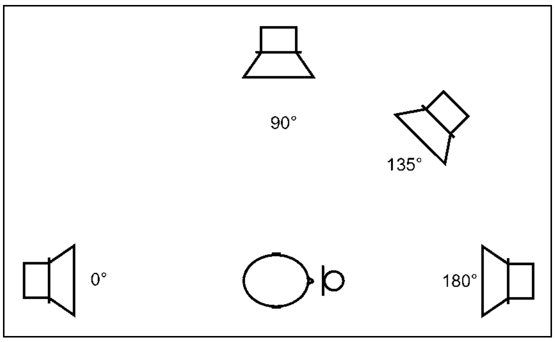

Figure 1 Measurement setup in the anechoic chamber

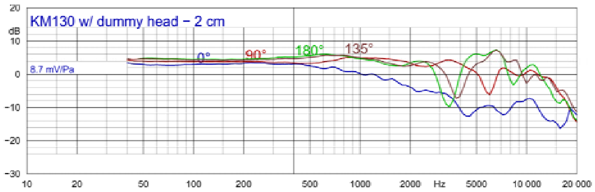

Figure 2 Omnidirectional microphone and dummy head

The dummy head does not have the identical acoustical properties of a real human head. To ensure correlation, the measurement was repeated with a real human acting as obstacle (figure 3).

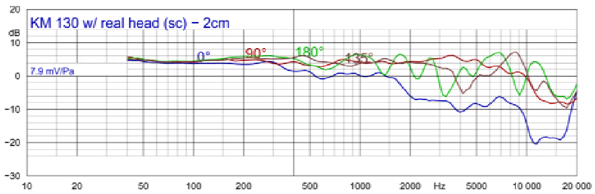

Figure 3 Omnidirectional microphone and real head & body

The measurements seem to correlate satisfactorily regarding reflective and diffractive effects so that further measurements were performed with only the dummy head in the setup shown in figure 4.

Figure 4 Setup with vocalist microphone and dummy head

2.2. Measurements

In real-life stage applications unidirectional microphones are used, typically with cardioid or super-/

hypercardioid directivity patterns. Such microphones can be developed with largely frequency independent polar patterns, as shown in figure 5.

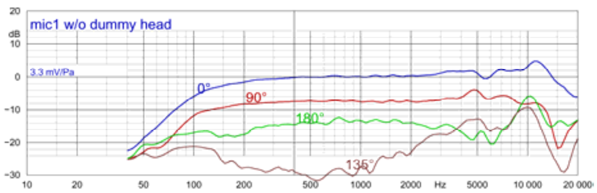

Figure 5 Frequency responses of a supercardioid vocalist microphone with uniform polar pattern

The directivity of such microphones produces further angle-dependant effects on the far-field frequency response, in the presence of a large spherical object in front of the microphone. Measurements with and without a dummy head as obstacle are shown in fig. 6.

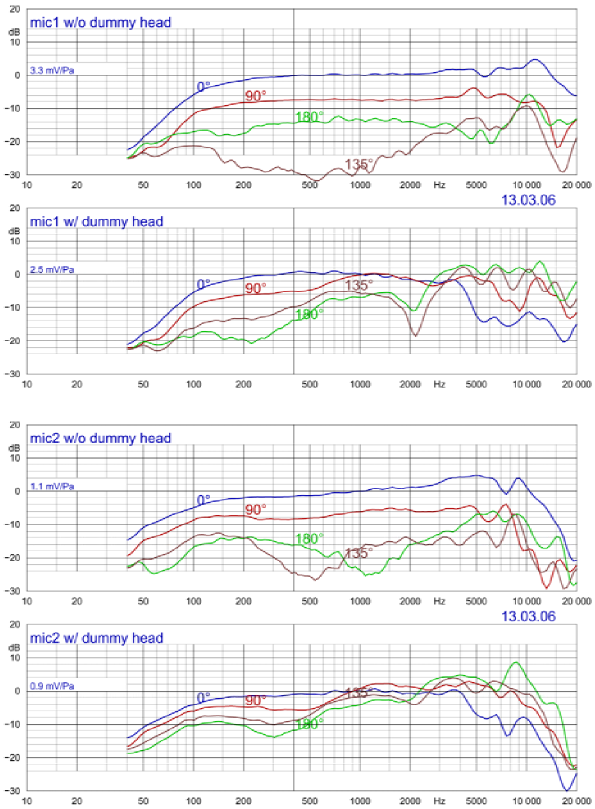

Figure 6a Measurements of vocalist microphones with and without dummy head

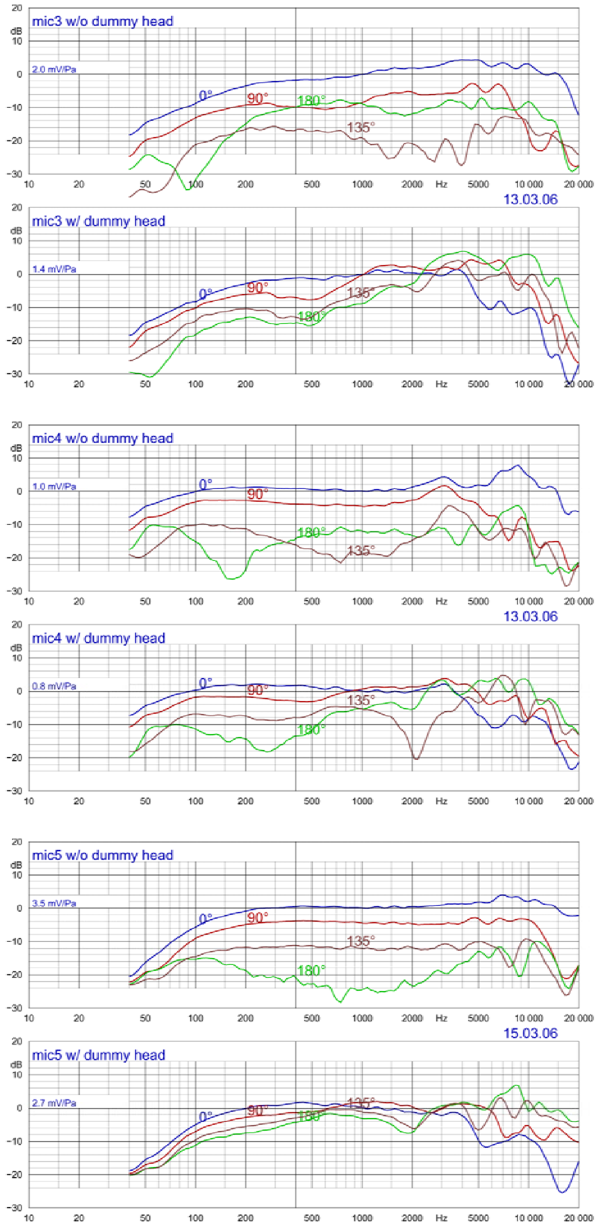

Figure 6b Measurements of vocalist microphones with and without dummy head

2.3. Results

A number of different effects can be seen in these curves. Analysing different angles of sound incidence, one can say that

- for 0° sound incidence, the head shades off a relevant part of the high frequent sound waves, leading to a roll-off in the treble response,
- for lateral angles, an increasing part of the sound waves is reflected into the front sound entry port of the microphone, altering the polar pattern,
- for 180° sound incidence, the head reflects a large part of the sound energy back into the front sound entry port of the microphone, causing the rear sensitivity to actually be higher than the front sensitivity.

From a frequency point of view, the results are:

- for low to mid frequencies, the directivity index decreases in all tested microphones. The cardioid becomes a sub-cardioid, the super-/hypercardioid becomes a cardioid,
- for high frequencies, the head shades off frontal sound, but reflects sound from the rear so as to almost reverse the polar pattern of the microphone and make the microphone directive towards the rear.

Essentially, the measurements described above imply that for vocalist microphones three sets of frequency response curves, or alternatively polar patterns, are helpful to approximately describe the real-life behaviour of the microphone

- to describe the response of the microphone to the singer: the near field response, as is usually measured with an artificial mouth according to ITU-T P.51: 1996 Artificial mouth
- to describe the response of the microphone to distant sound sources, in the absence of a person in front of the microphone: the far field response, as is usually measured in an anechoic chamber, with plane waves, following IEC 60268-4 Sound System Equipment – Microphones.
- to describe the response of the microphone to distant sound sources, with a person in front of the microphone: the far field response, measured with a head-like obstacle in front of the microphone.

Additionally, complete or rear half-room diffuse-field measurements could be envisaged to describe with a single, summarizing curve the sonic effects of the head on microphones.

3. SUMMARY

It is often stated that cardioid vocalist microphones should be used in stage applications where the stage monitors as one main source of acoustic feedback are located directly behind the microphone, i.e. at 180° sound incidence and in the null of the directivity pattern. Likewise, the super-/hypercardioid is recommended for the case where the monitors are situated at an angle to the microphone, with the microphone's sensitivity null between 120° and 135°. These arguments seem not take into account the presence of the singer in front of the microphone. For practical application the described measurements imply that super-/hypercardioid microphone types are to be generally favoured for live applications. This not only because of their often quoted superior attenuation of diffuse sound components, but especially because of their still retaining an over-all higher frontal directivity at low to mid frequencies, even in the presence of a vocalist in front of the microphone.

4. ACKNOWLEDGEMENTS

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