What You Need to Know About Microphone Polar Patterns

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It's not only "the right mic for the right job"—you also need to choose the right polar pattern

By Phil O'Keefe

I often like to draw analogies between photography and recording. In particular, I often compare microphones to a photographer's lenses. They are the primary tool we use to capture our sonic images, and like lenses, no single microphone is right for every situation. Some lenses are optimized for a capturing a wide field of view, while others are much better at focusing in tightly on a smaller angle of view. Microphones have similar characteristics in that some are designed to pick up "everything," while others are much more specialized and designed to capture sound that arrives from some directions, while rejecting or attenuating sound that arrives from others. Additionally, some microphones significantly "color" or change the sound that arrives off-axis. Furthermore, stereo microphone techniques often combine two or more microphones - sometimes with completely different polar patterns - to capture the stereo soundfield. For these reasons, a good basic understanding of polar patterns is extremely important, and crucial to getting the most out of your microphones.

UNDERSTANDING POLAR PATTERN PLOTS

Microphone polar patterns are often published by their manufacturers in a two-dimensional diagram form that attempts to show a three-dimensional, 360 degree field surrounding the mic. The plot is drawn out as if the microphone were located at the center, and "aimed" or pointed at the 0 degree point on the graph. (Figure 1) This is the "on-axis" point for the microphone, with 90 and 270 degrees being directly to either side of it, and the 180 degree point directly to its rear. A plot line on the graph shows the microphone's sensitivity to sound arriving from different directions. Where the plot line shows up relative to the polar plot's concentric circles shows the microphone's sensitivity to sounds arriving from that angle. If the plot line remains on the outer edge of the outer circle, there is no attenuation, while each ring closer to the center represents 5dB of attenuation in the response. The closer the plotted line is to the center of the graph, the less sensitive the microphone is to sounds arriving from that angle. The pattern shown in Figure 1 is a "cardioid" (literally "heart-shaped") pattern, and is most sensitive to sound arriving at 0 degrees, on-axis, or from directly in "front" of the microphone, while it is least sensitive to sounds arriving from 180 degrees, or directly to the "rear" of the mic. If you have a SM58 or similar cardioid microphone, you can try it yourself - sing into the center of the ball from about 6" away, then flip it upside down and try to sing directly into the other end of the mic, with your mouth right next to the cable's XLR connector. The distance from your mouth to the mic element is about the same in both cases, but the amount of volume you hear will be drastically different due to the cardioid pattern's attenuation of sound arriving from the rear.

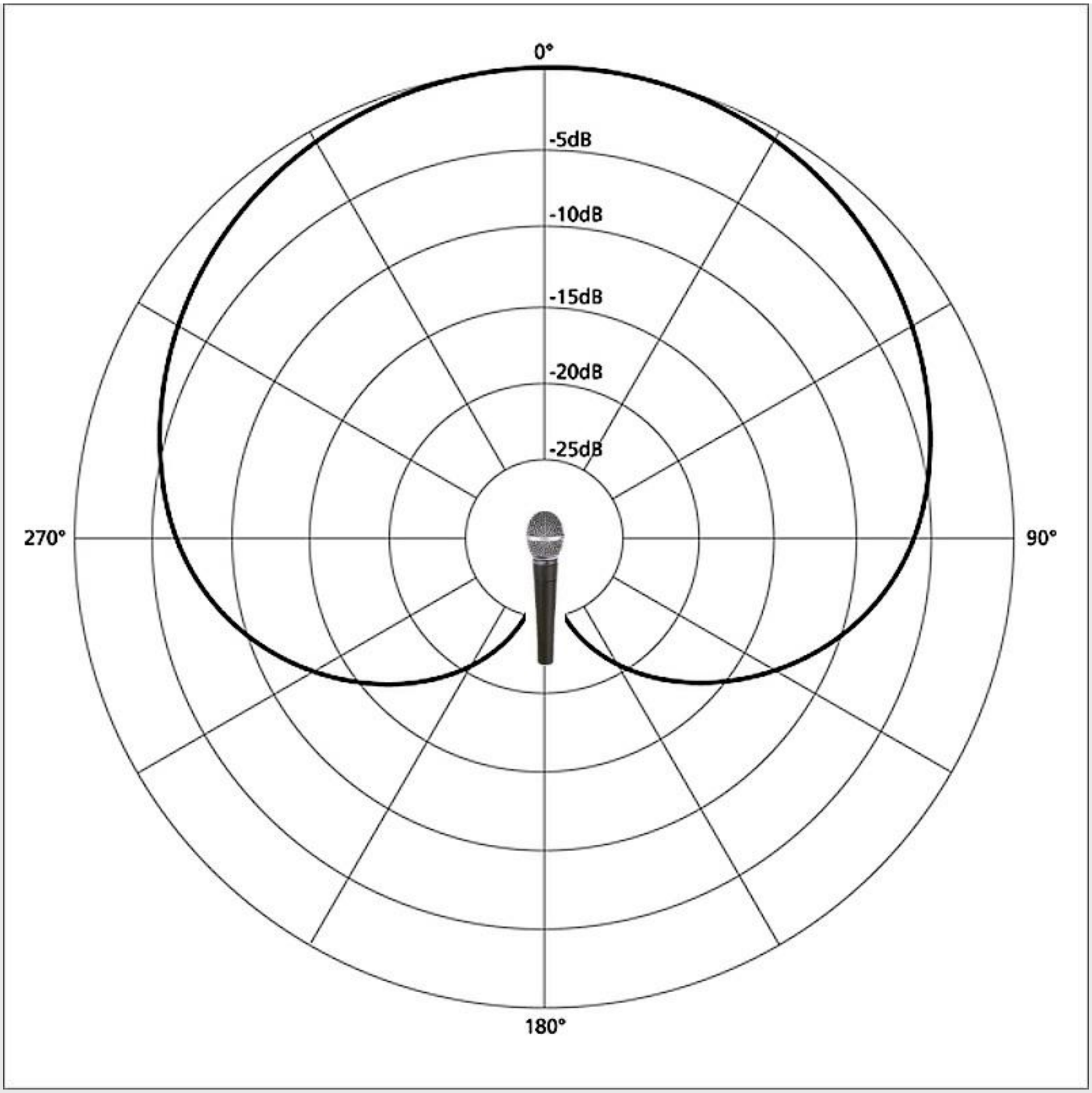

Figure 1: A typical polar pattern plot, showing the orientation of an end-address microphone relative to the plot (click on images to enlarge)

Since polar patterns tend to vary at different frequencies, often more than one plot is drawn out on a single graph, with the response at different frequencies represented by different types of lines - for example, different colored lines, or solid lines, dashed lines, and dots and dashes may all be used on a single plot to represent the microphone's polar pattern and response at different frequencies.

THE BIG THREE

The majority of microphones on the market use omnidirectional, cardioid, or figure-8 polar patterns. While other patterns exist, these three are by far the most popular. Many microphones have a single, "fixed" pattern, while some microphones offer interchangeable, removable capsules with different polar patterns, while still others have multiple patterns that can be selected by the user - usually via a small switch on the microphone body, or in the case of some tube mikes, a similar knob or switch on its remote power supply. Let's take a closer look at each of these three patterns.

Omnidirectional: An "ideal" omnidirectional microphone responds evenly and equally to sound arriving from any angle, and at any frequency. (Figure 2) Omnidirectional microphones also have no proximity effect, so there is no loss of bass response with increased placement distance from the sound source. They have no off-axis coloration either, which means that they tend to offer the truest, most accurate representation of sounds across the frequency spectrum. If you're looking for a "natural" sound, an omni mic usually can't be beat. This makes them very popular for classical and jazz recording. The ratio of direct sound from whatever you're recording to ambience and reverb from the room can be easily adjusted simply by moving the mic closer to or further away from the sound source, but this means "omnis" also tend to capture more of the sound of the room's character than other polar patterns, and therefore they work best in acoustically good sounding rooms. Because they pick up sound arriving from all angles equally well, they are not good for feedback rejection, and are not often used in live sound reinforcement situations because of this, but in the studio, or for live recordings, they are excellent for capturing natural, uncolored sound, and are frequently used in AB Stereo or "spaced pairs."

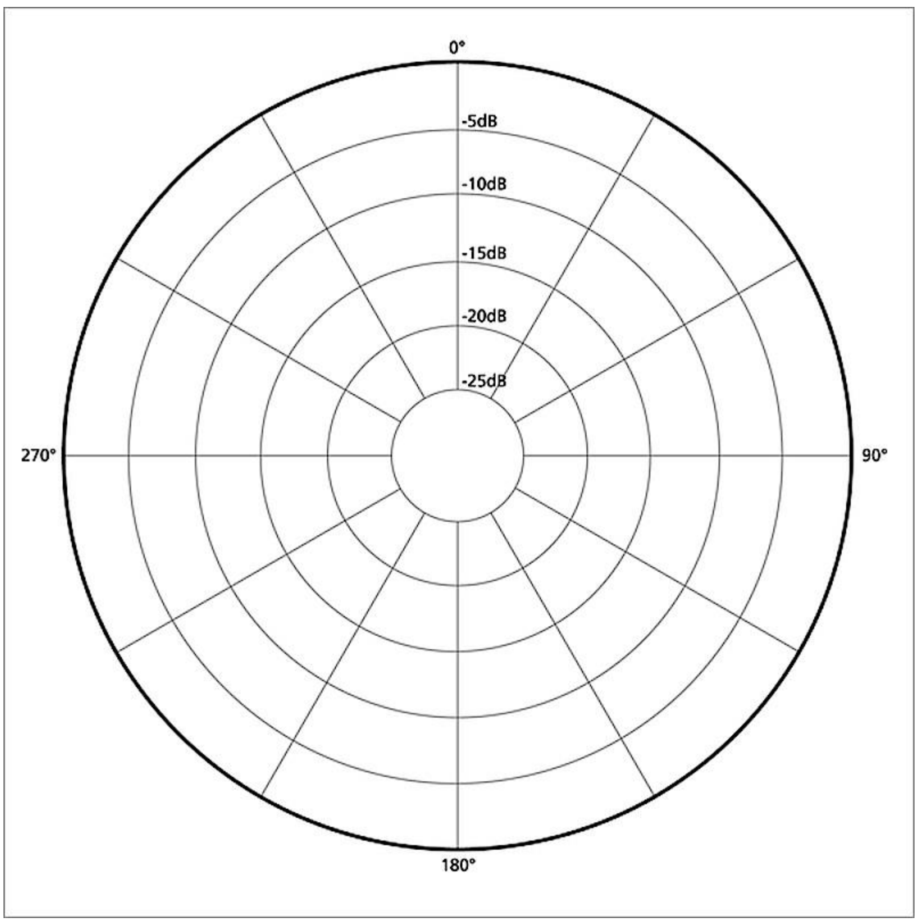

Figure 2: Omnidirectional microphones evenly capture sounds arriving from any direction

Cardioid: Most microphones today feature a cardioid polar pattern. (Figure 3) Cardioid mikes are most sensitive to sound coming directly from the front, and less sensitive to sound arriving at the rear of the microphone. This makes cardioid mikes very useful for live performances, where sound arriving at their rear (typically from stage monitors and PA speakers) is attenuated, thus helping to prevent feedback. This is a classic example of using a microphone's polar pattern to your advantage. Place the mic so it is aimed directly at the singer, but also so that the "back" of the microphone is simultaneously aimed at the singer's onstage monitor speaker. Off-axis coloration can be an issue with many cardioid microphone models, which can be a problem when recording multiple sound sources in the same room. Increasing the distance between the microphones can help reduce this. A cardioid mic's "null point" can be equally useful in the studio. For example, by placing two musicians so that they're facing each other, but on opposite sides of the room, and then aiming a cardioid mic directly at each, it's often possible to record more than one person at a time in the same room while still retaining relatively good isolation. Cardioid microphones are often used for stereo miking setups, including XY stereo and ORTF stereo configurations.

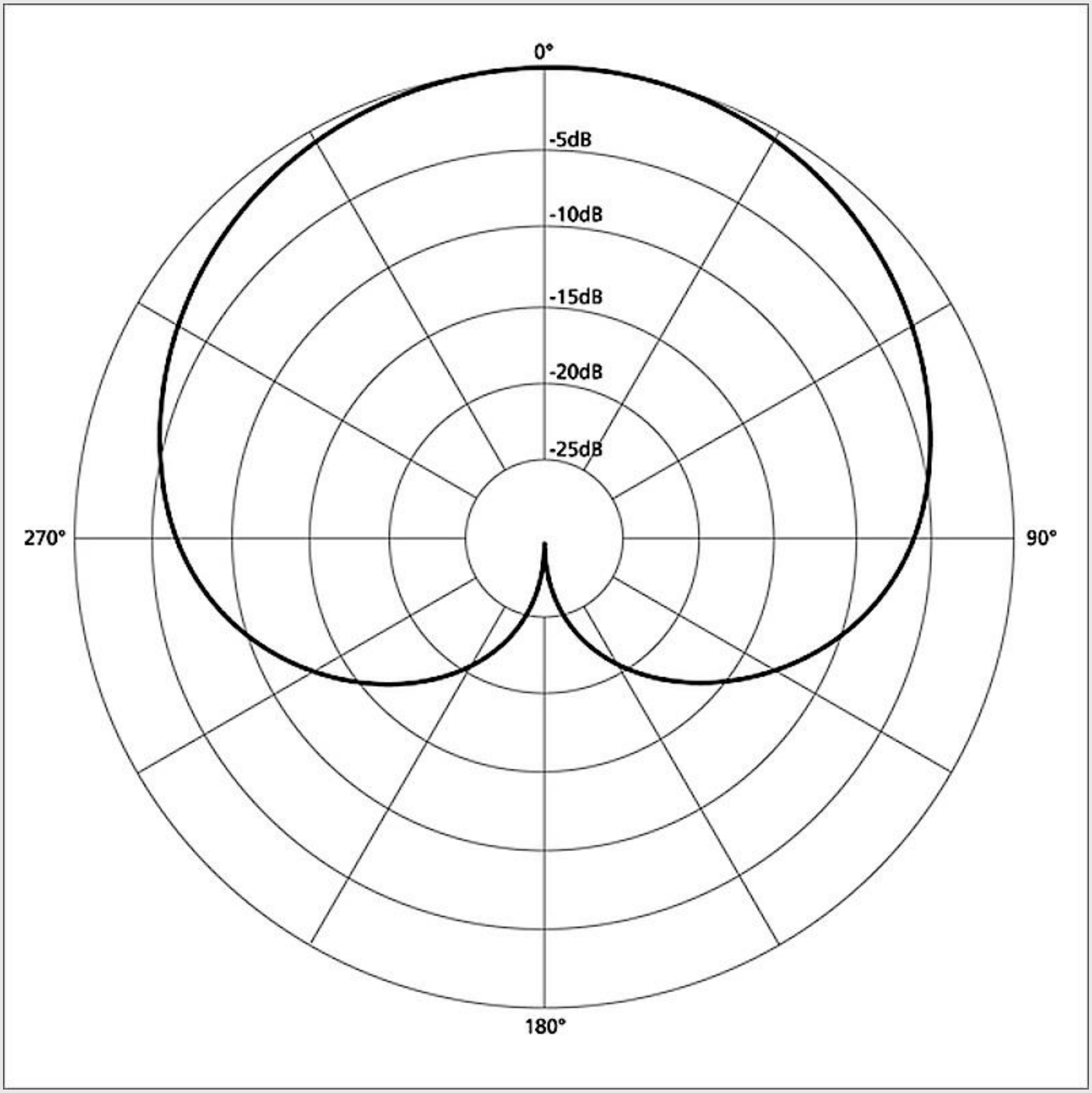

Figure 3: A cardioid polar pattern. Note the decreased sensitivity to sounds arriving at 180 degrees - the "rear" of the mic

Bi-Directional: Microphones with Figure-8 or Bi-Directional polar patterns (Figure 4) are less commonly seen today than omnidirectional and cardioid mikes, but they are still extremely useful. Most ribbon microphones have bi-directional polar patterns, as do many high-end multi-pattern large diaphragm condenser microphones. They have quite significant proximity effect, which means the closer you place them to the sound source, the more the low frequencies will be "boosted." You can use this to good effect to "fatten up" thin sounding singers and instruments. Bi-directional microphones have the best rejection at the null points of any polar pattern - you can get nearly perfect rejection of sounds arriving from the sides with many ribbon microphone models. This can make them a great choice when you have two things in close proximity that you want to record on to separate tracks, while still maintaining a good degree of separation and isolation between them. For example, if you are getting too much hi-hat bleed into the snare mic, try using a figure-8 mic on the snare and angle it in such a way that the hi hat is to the "side" of the snare mic, and the snare is directly in front of it. You'll get tons of snare on the recording, and a lot less hi hat bleeding into the snare mic than if you had used a cardioid mic instead. Bi-directional microphones are also a crucial component of many stereo mic configurations, including Blumlein stereo and Mid-Side stereo.

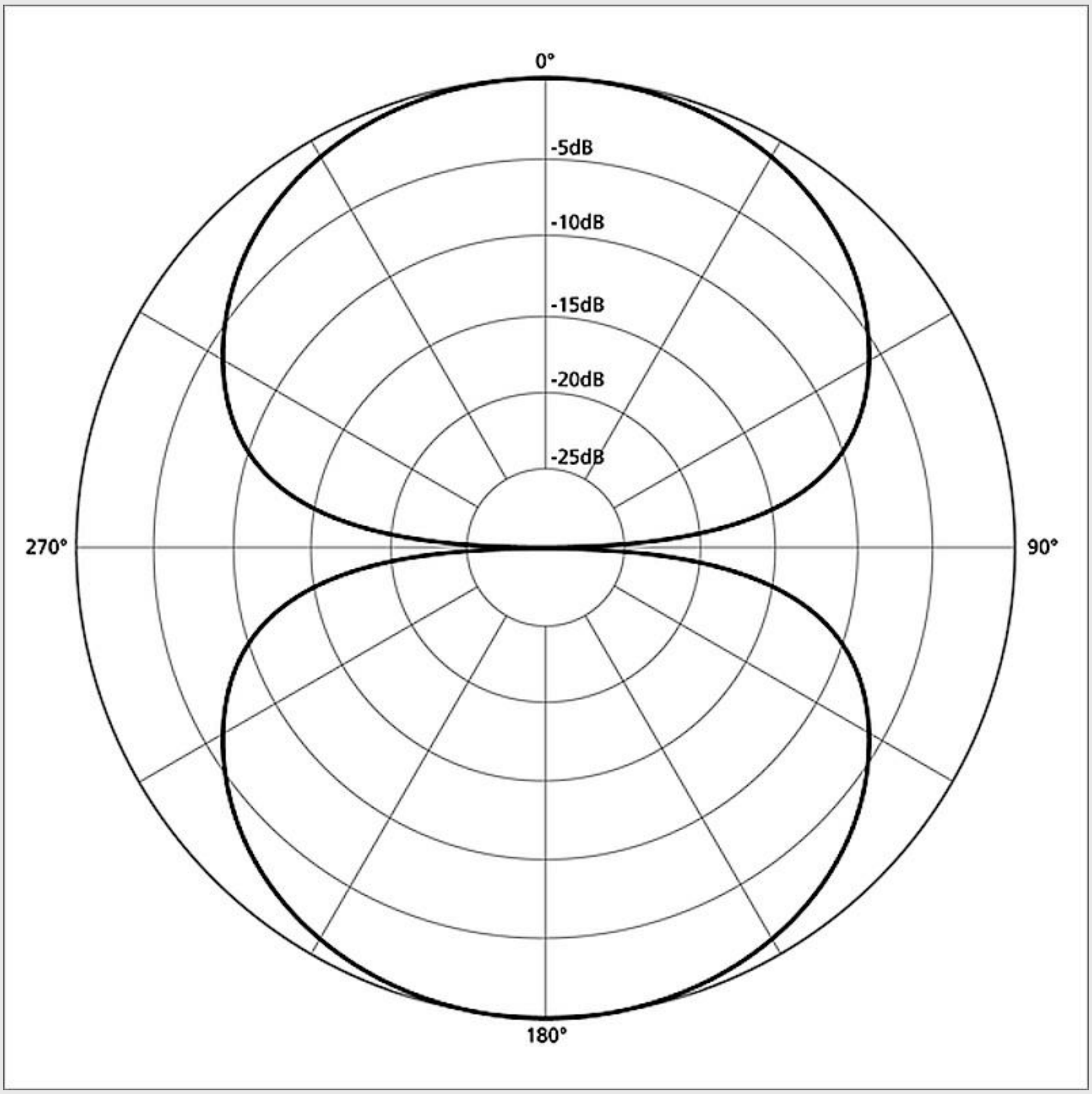

Figure 4: A Figure-8 polar pattern typically has perfect or near perfect rejection of sound arriving from the sides

OTHER PATTERNS

There are several other polar patterns, but most of them are really just variations on the three primary types.

Subcardioid: Also known as a "wide cardioid" pattern. It generally sits somewhere in between an omni and a cardioid in shape, with less rear rejection, and more sensitivity to sound arriving from the sides than a standard cardioid microphone, and somewhat more directionality than an omni mic.

Supercardioid: Also similar to a cardioid pattern, but with increased directionality, and some increased sensitivity to sound arriving from the rear, but not quite as much so as with a Hypercardioid pattern (see below.) Typically, their best rejection is to sound arriving at 150 degrees and and 210 degrees - not quite from "dead behind" the mic, but close to it.

Hypercardioid: Like the quite similar Supercardioid pattern, it is more directional than a cardioid, and has even greater sensitivity to sound arriving from the rear than the supercardioid does. This pattern can be thought of as somewhere between a cardioid and a figure-8 pattern in terms of overall directionality. (Figure 5)

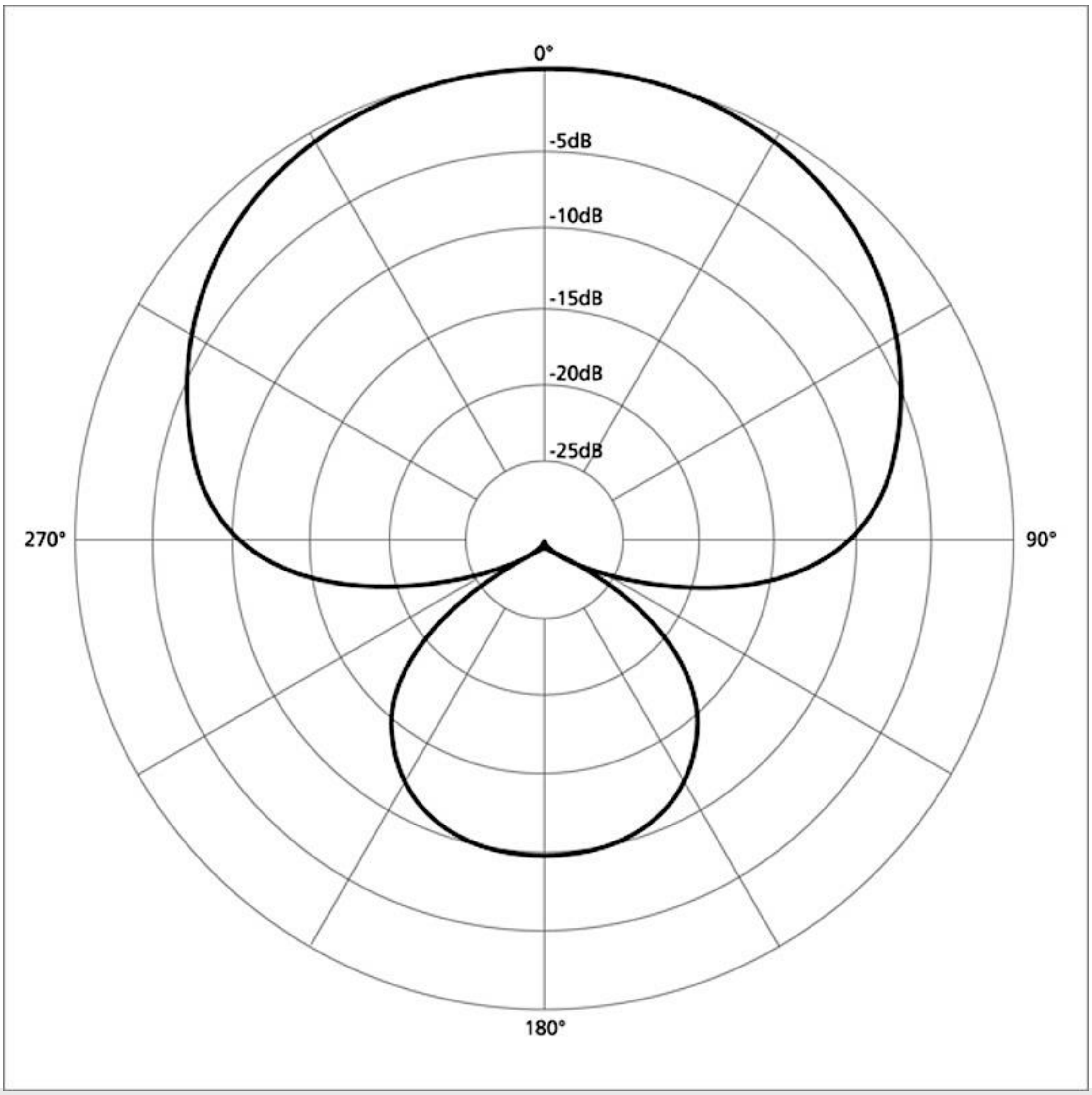

Figure 5: A hypercardioid polar plot. Notice the similarities and differences between it and the cardioid and figure-8 polar patterns. Best rejection is at 120 and 240 degrees off-axis

REJECTION - IT'S ALL IN THE ANGLES

In closing, remember that It's not just where you aim the front of the microphone that matters. What you aim it away from - or more precisely, where you aim the null points - the "dead spots" in the polar pattern - can also make a big difference in your recordings. So pull out those manuals, or fire up the computer and check the websites of the people who made your mikes and study their polar patterns. Then start experimenting with different mic placement angles on your recordings, with an ear towards not only want you want to capture, but also what you want to reject.

Phil O'Keefe is a multi-instrumentalist, recording engineer / producer and the Associate Editor of Harmony Central. He has engineered, produced and performed on countless recording sessions in a diverse range of styles, with artists such as Alien Ant Farm, Jules Day, Voodoo Glow Skulls, John McGill, Michael Knott and Alexa's Wish. He is a former featured monthly columnist for EQ magazine, and his articles and product reviews have also appeared in Keyboard, Electronic Musician and Guitar Player magazines.