

# Polar pattern accuracy of some HOA Microphones

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# 1 Purpose

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- The purpose of this document is to provide some idea of the accuracy of the polar patterns of some Higher Order Ambisonics microphones. All aspects of Ambisonics technology (rendering on speakers or binaural, virtual microphones, . . .) depend strongly on how accurate the polar patterns corresponding to Spherical Harmonics are. Other quality metrics (e.g. frequency response) can be corrected by post-processing, but for the polar patterns this is not possible.
- All HOA microphones have a limited frequency range for the higher order components.
  - \* At the lower frequency side this is because extracting the higher order components from the available capsule signals requires the amplification of small differences between the capsule signals. This will also amplify noise and calibration errors, so there will be a limit to the amount of gain that can be used. The required gain increases by 12 dB/oct for 2nd order, and 18 dB/oct for 3rd order.  
For binaural rendering this is usually not a problem, as HRTF do not depend on the higher order components at low frequencies (below around 500 Hz).
  - \* At the higher frequency side, the actual distance between the capsules imposes the limit, for all orders. If this distance is higher than half a wavelength, spatial aliasing will make it impossible to obtain the required polar patterns. Also the actual construction of the array may introduce problems at high frequencies, due to diffraction and reflection effects.  
This *does* matter for binaural reproduction.

## 2 2nd order microphones

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### Core Sound Octomic

- The Octomic uses 8 near-cardioid electret capsules, mounted in a very small array. The microphone body is very slim, and the way the array is constructed is designed to avoid all acoustical obstructions near the capsules and their back ports.
- The A/B processing algorithm for the Octomic provides 2nd order AMB components with the exception of the ACN 6 (R) component. So it is effectively 2nd order in azimuth and 1st order in elevation.
- Each Octomic comes with an individual set of calibration parameters and filters to be used by the A/B processor. These are computed from a large number of measurements done by Core Sound. This results in very accurate frequency response and polar patterns.

### Voyage Audio Spatial Mic

- This uses an array similar to the Octomic, but in a much larger microphone body. Measurements indicate that this seriously affects the performance of some of the capsules, and the results of this are clearly visible in the plots presented on the following slides.
- Normally the only calibration information available related to the gain of the capsules, and this is stored inside the microphone.
- For this report, the Spatial Mic was calibrated using the same measurements and procedure as used by Core Sound for the Octomic. The results are therefore significantly better than what would normally be available to an end user.

# 3 3rd order microphones

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## MH Acoustics Eigenmike

- The Eigenmike uses 32 high quality omnidirectional capsules mounted on a rigid sphere of 84mm diameter. The solid sphere provides directionality at higher frequencies only.
- It can in theory provide up to 4th order Ambisonic signals, but the frequency range for 4th order is too small to be useful.
- The gains of the capsules are calibrated and stored inside the microphone. No other calibration is done for each individual mic, but the expected spread of capsule parameters is small.
- Since there is no significant capsule directivity at low frequencies, extracting even the first order AMB components requires significant gain.

## Zylia ZM-1

- The ZM-1 uses 19 MEMS capsules mounted on a solid sphere of 98mm diameter. Its working principle is similar to the Eigenmike.
- The A/B processing provides all 3rd order Ambisonic components.
- There is no individual calibration except for the capsule gains.
- As for the Eigenmike, extracting even the first order AMB components requires significant gain at low frequencies.

# 4 Measurement procedure

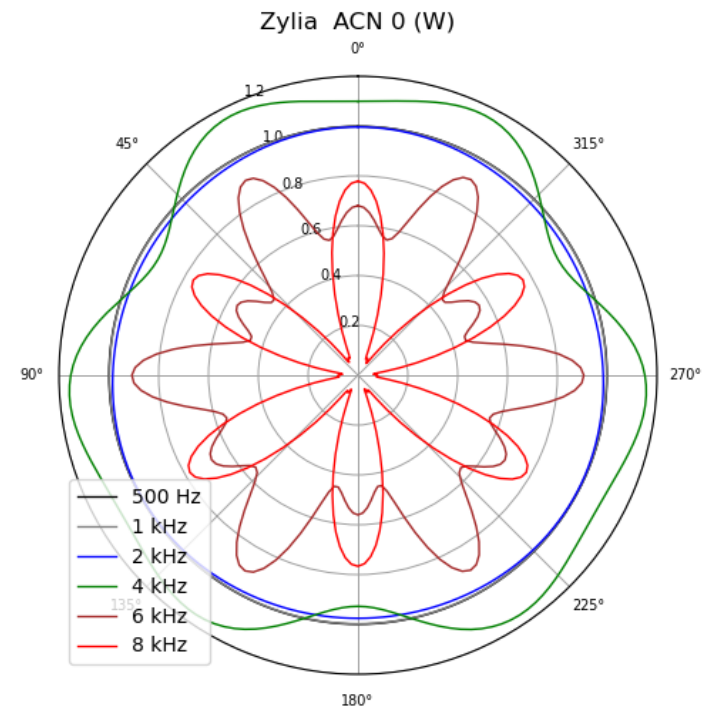
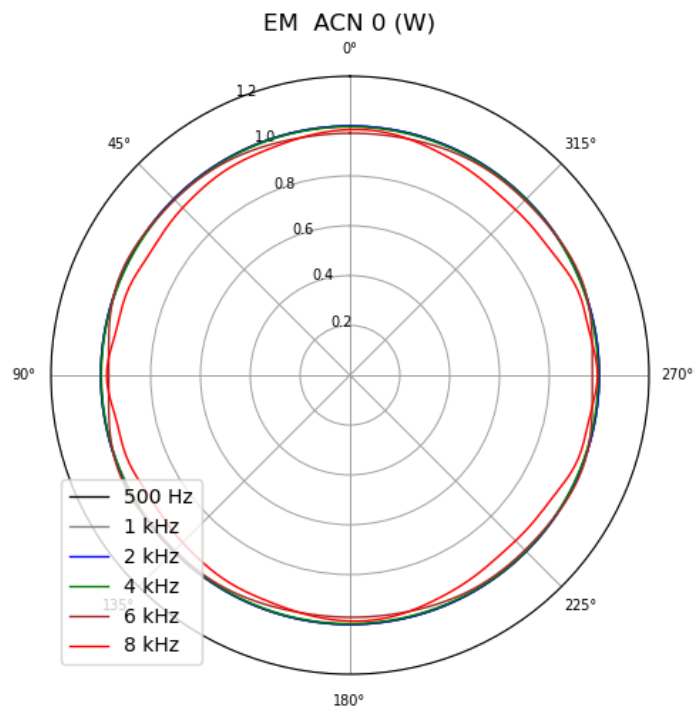
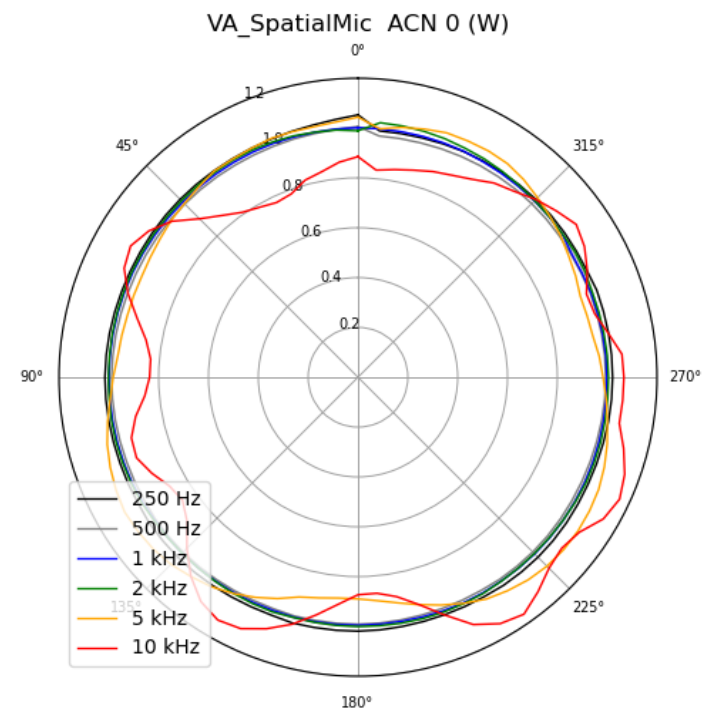
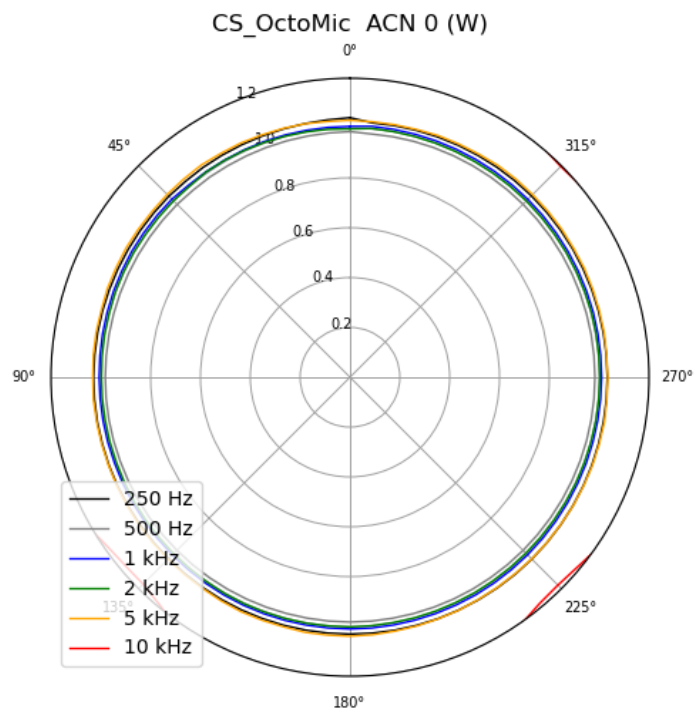
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When comparing the plots, the following should be kept in mind:

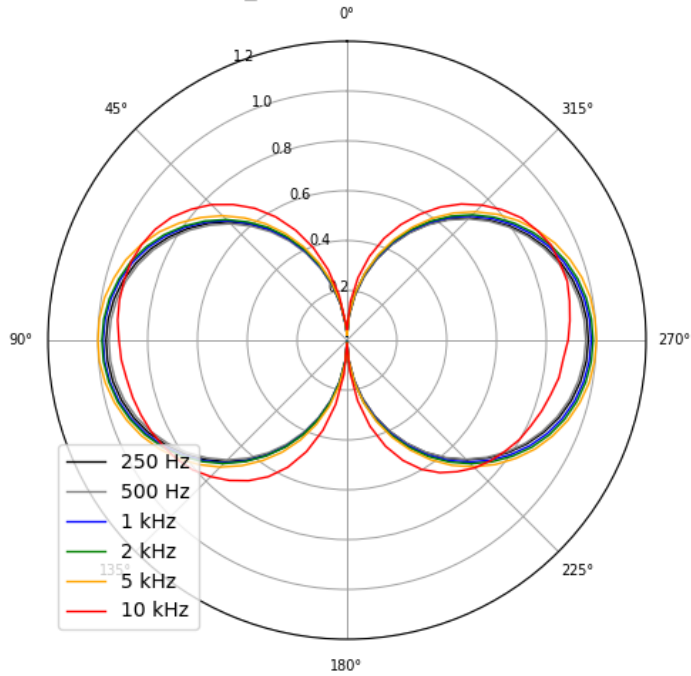
- The results shown for the Octomic and the Spatial Mic are based on [measurements](#) of an actual microphone, so they represent what can actually be expected in practice (but note that the Spatial Mic is normally not calibrated in the way it was for this report).
- For the Eigenmike and the Zylia ZM-1 no measurements are available, so the plots are the result of [numerical simulation](#) of the diffraction of a solid sphere, and assuming 'perfect' capsules. The real world is not perfect, and additional errors will show up in practice.
- The polar plots are *not* normalised to maximum or on-axis gain, so they include e.g. the effect of the low frequency cut-off for the higher order signals.
- The highest frequency for which usable polar patterns are available is different for each of the mics:

Octomic	$\geq 10$ kHz
Spatial Mic	$\approx 7$ kHz
Eigenmike	$\approx 9$ kHz
Zylia ZM-1	$\approx 5$ kHz

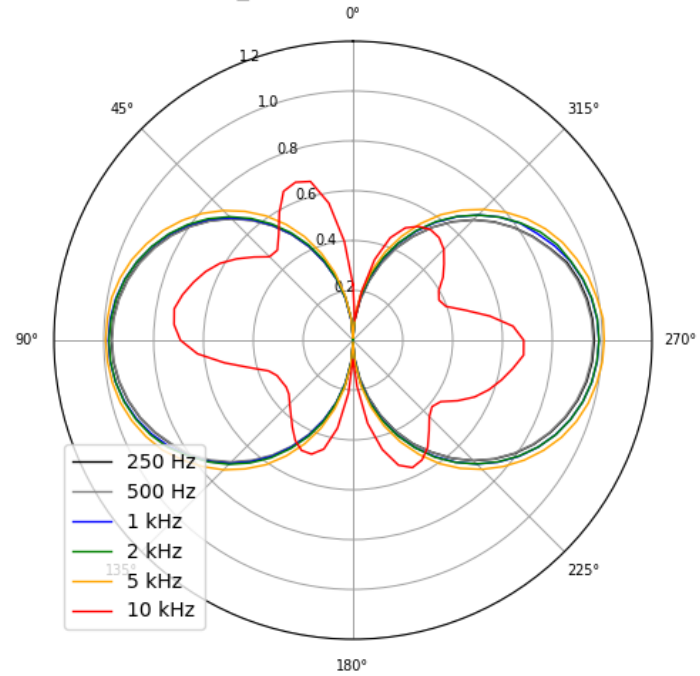
Note that for the 2nd order mics the highest frequency shown (in red) is 10 kHz, while for the Eigenmike and Zylia it is 8 kHz.



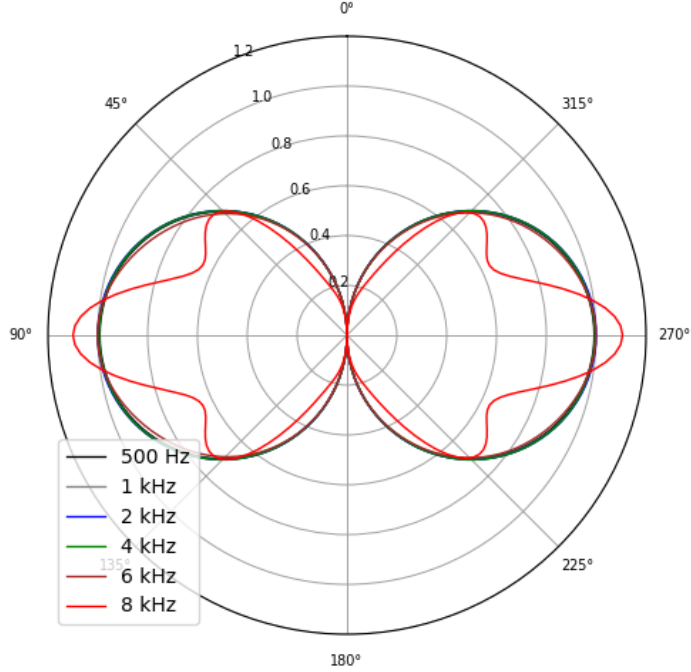
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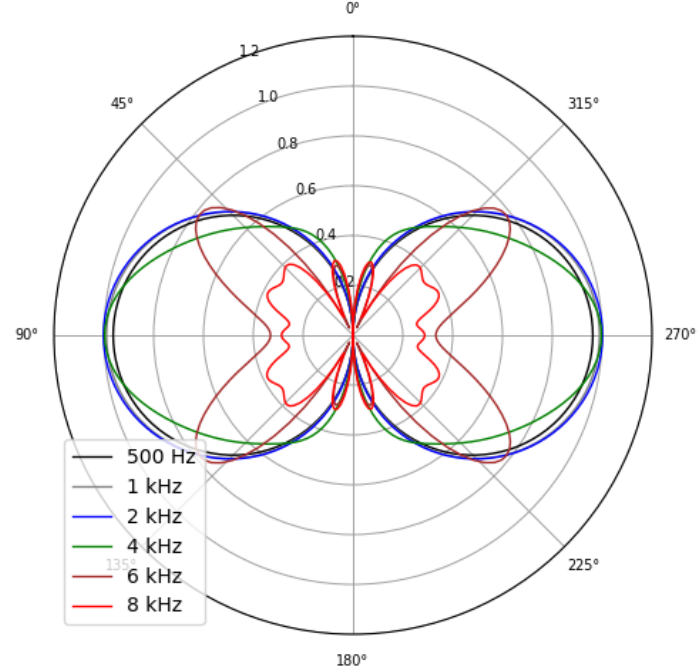
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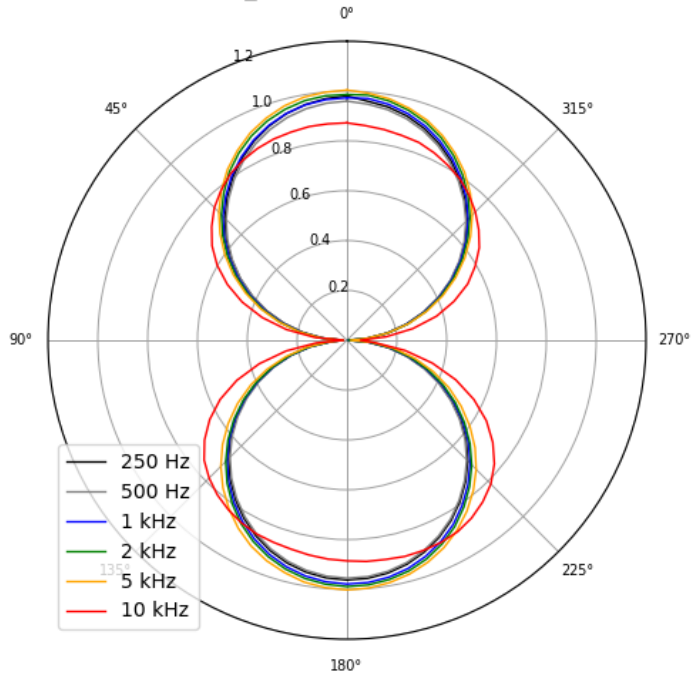
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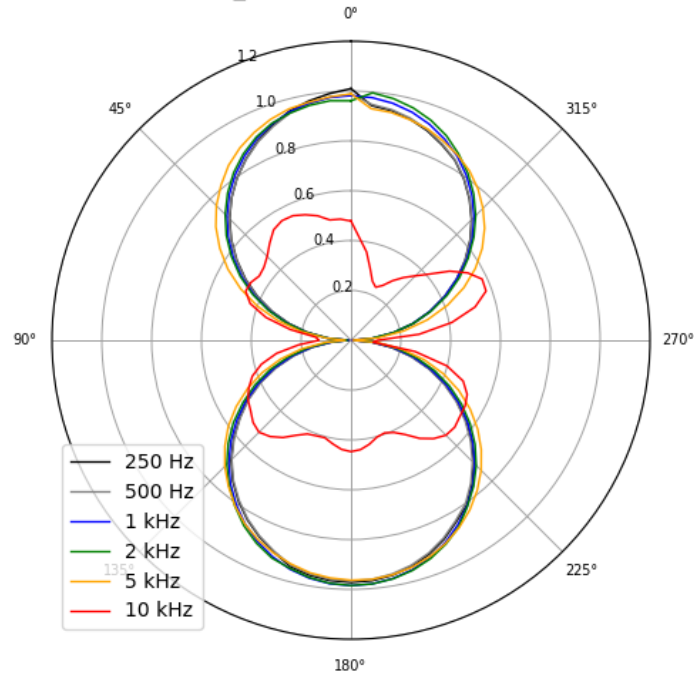
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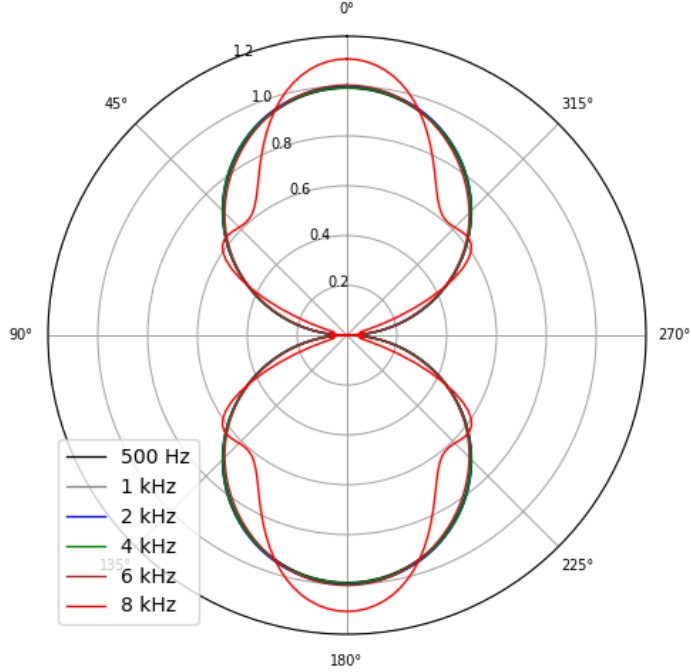
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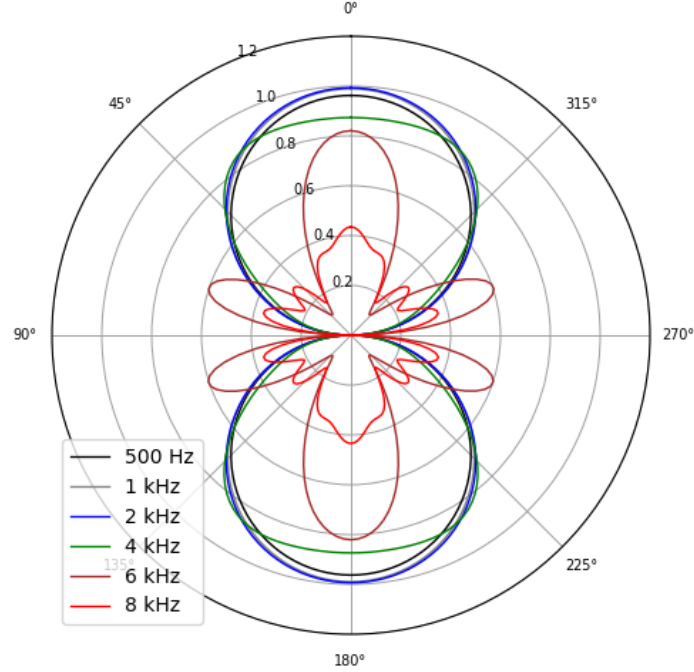
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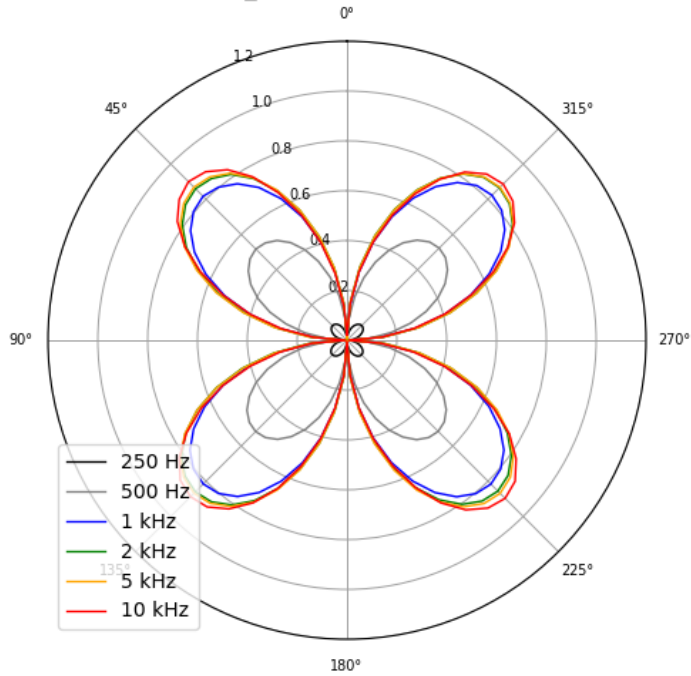
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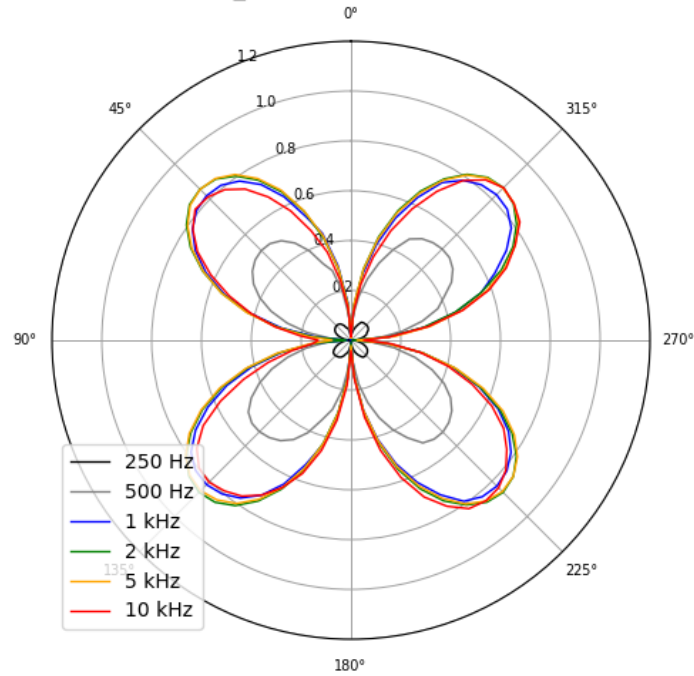
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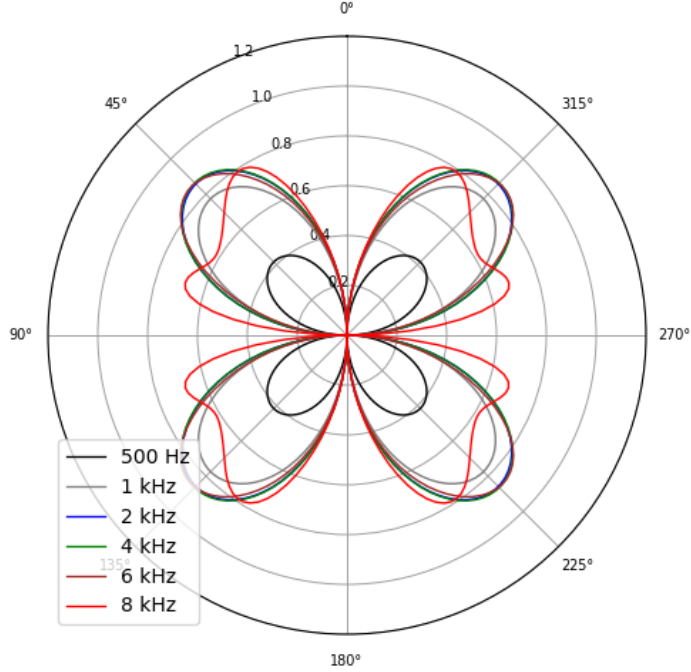
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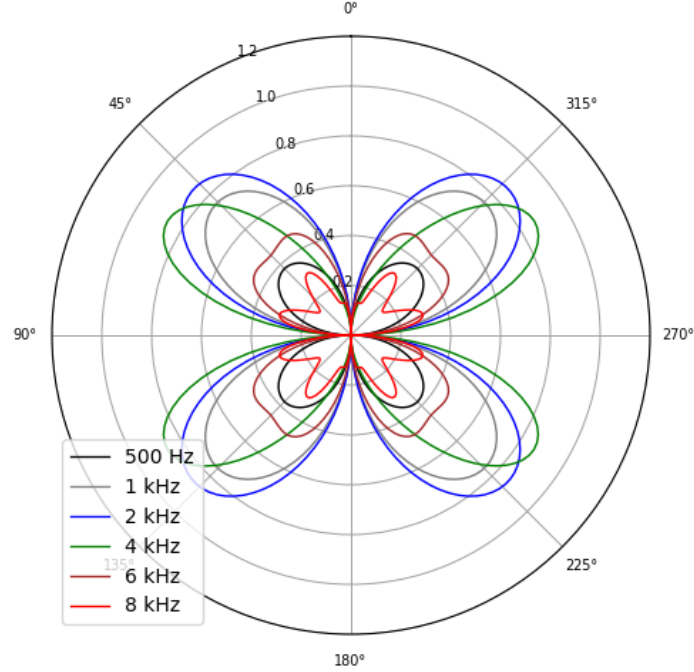
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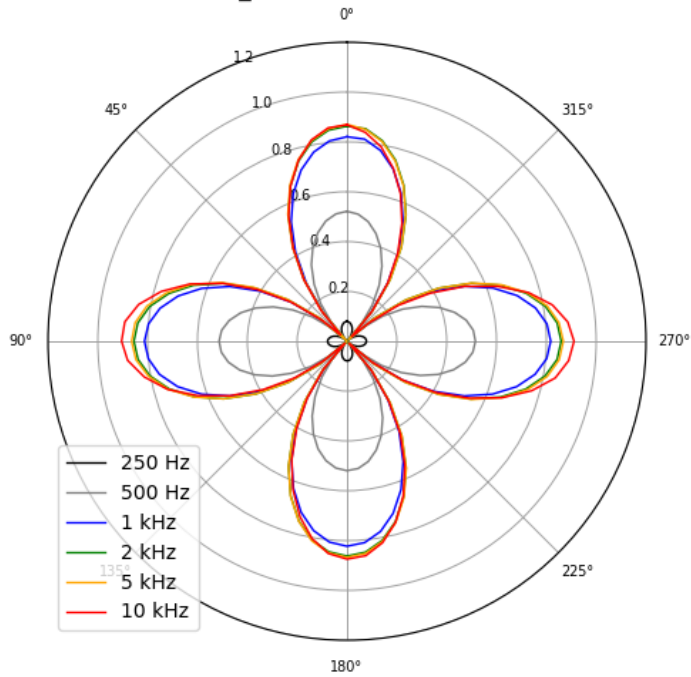
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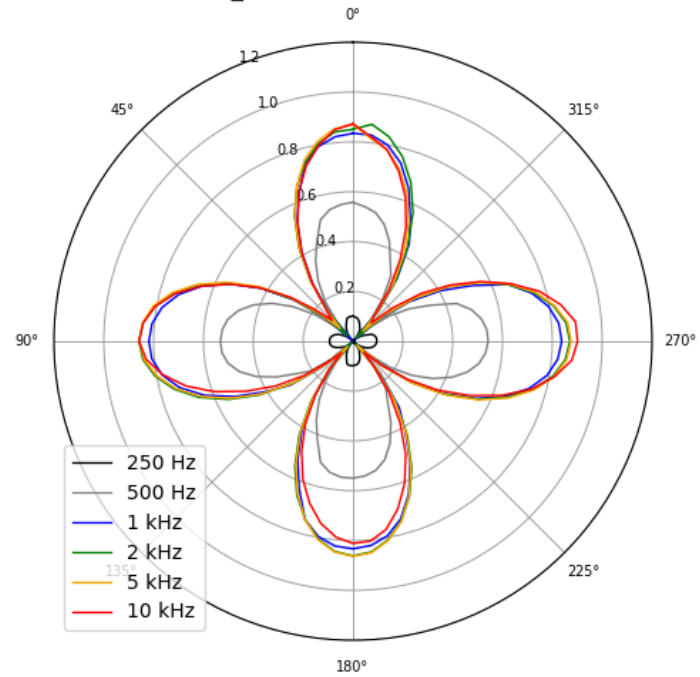
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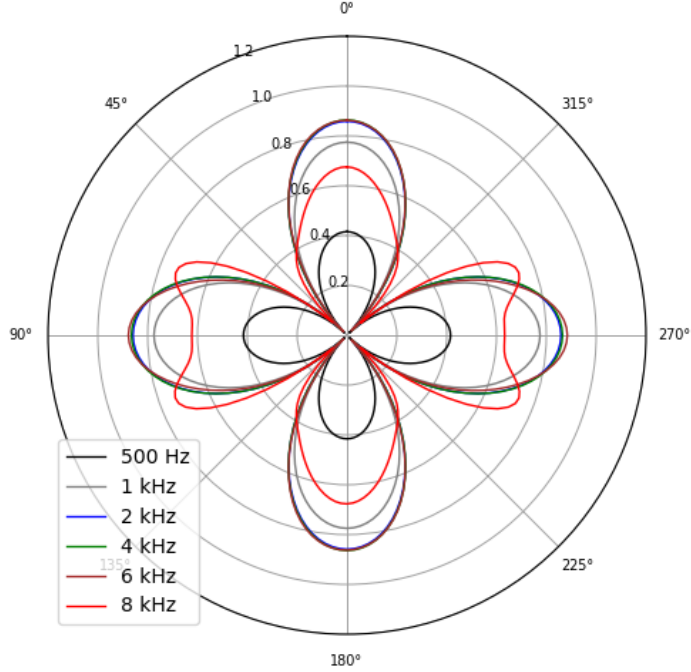
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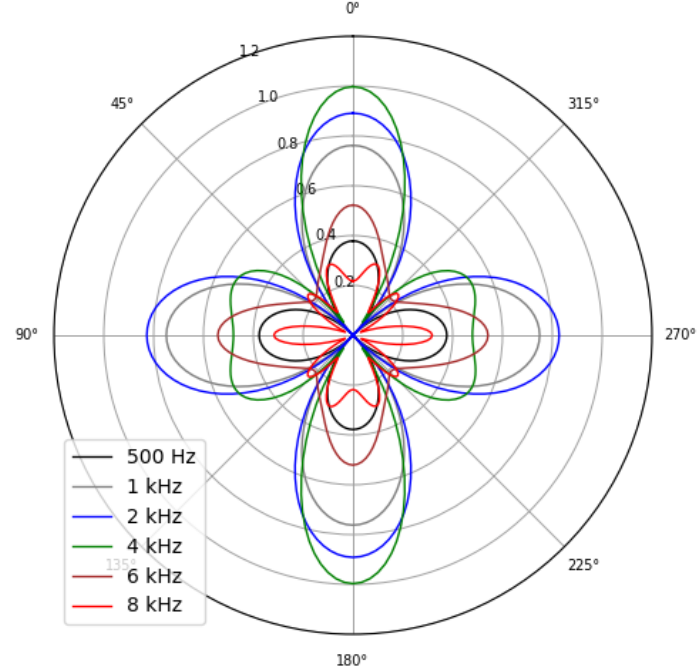
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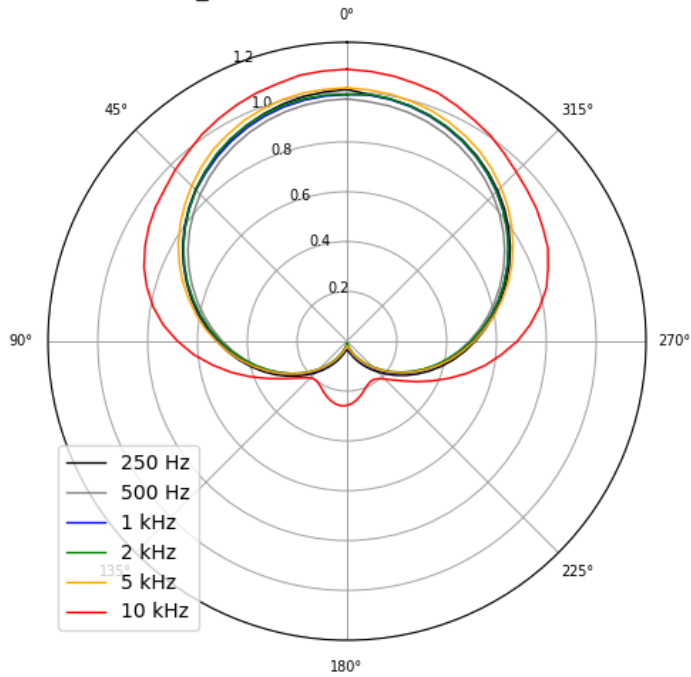
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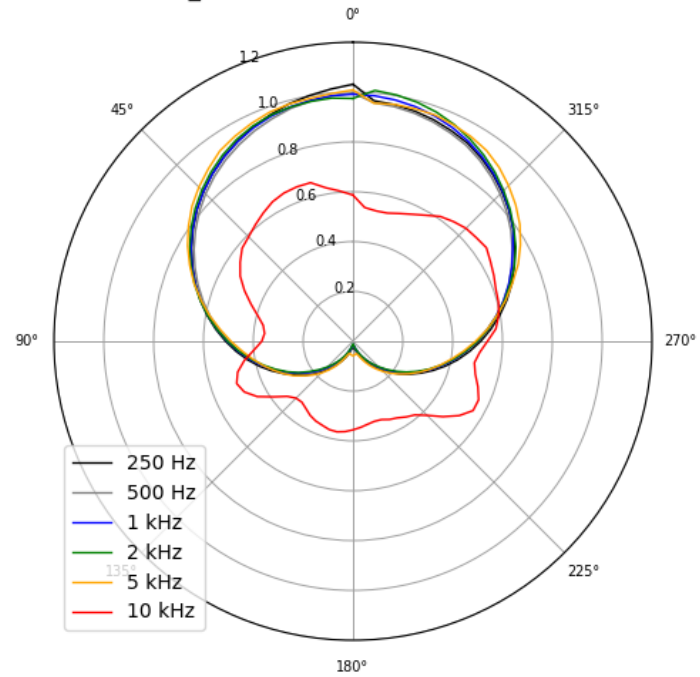
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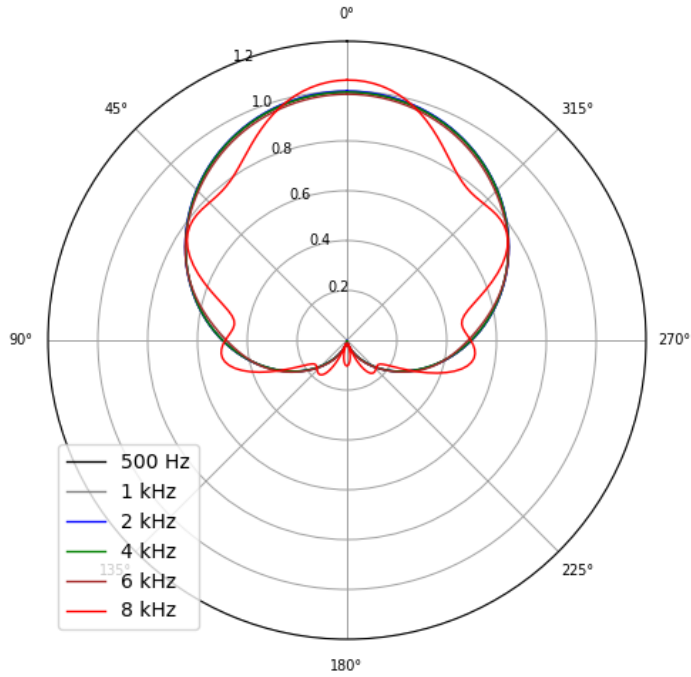
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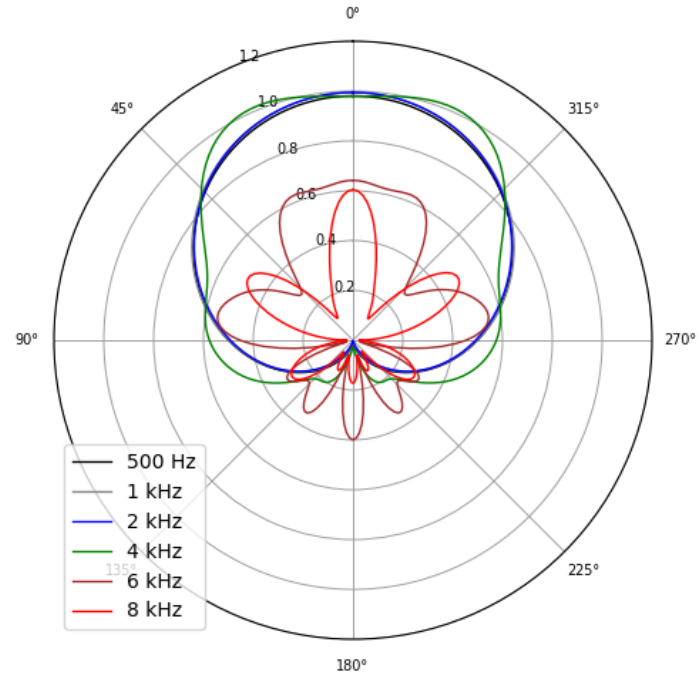
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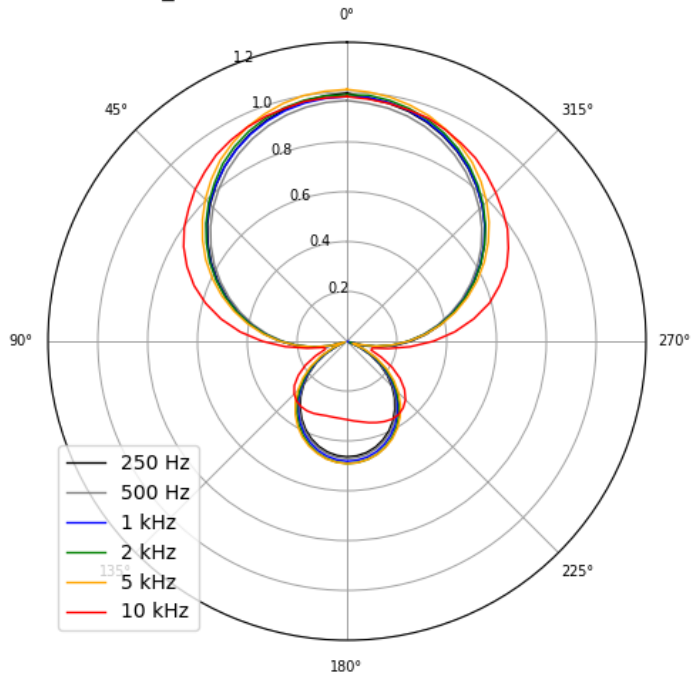
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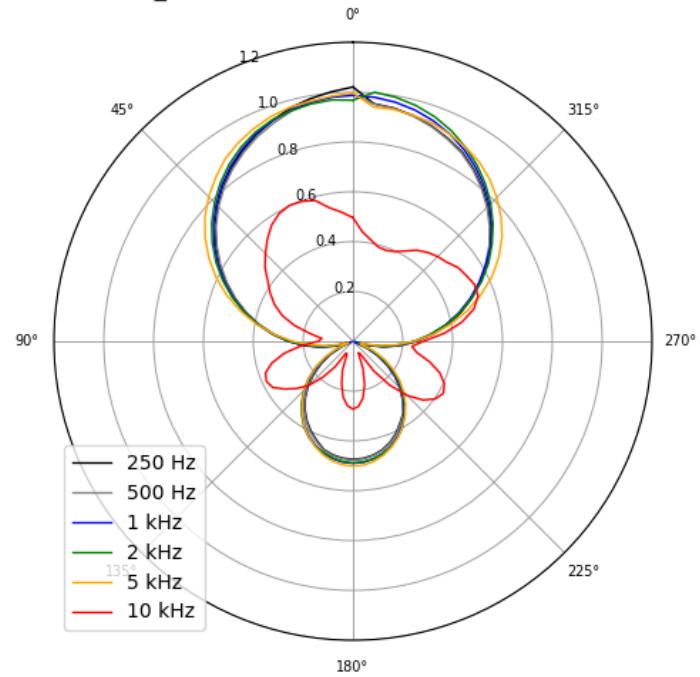
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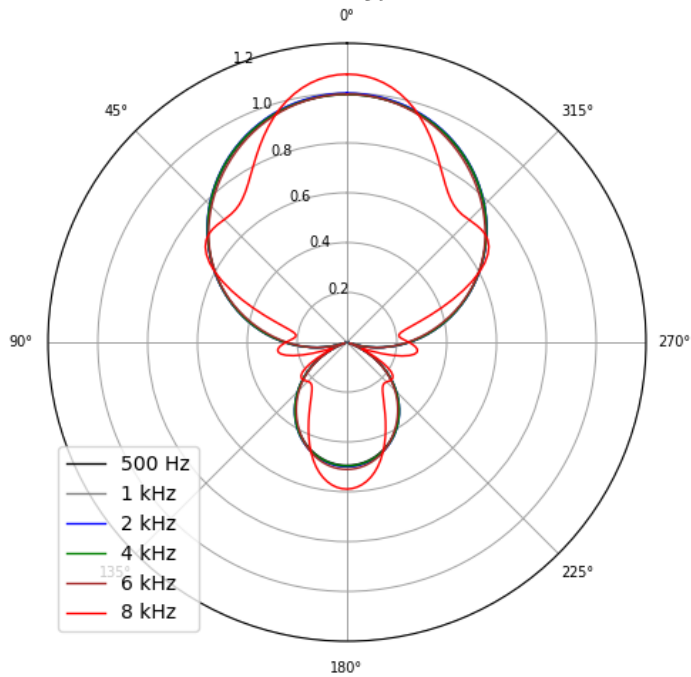
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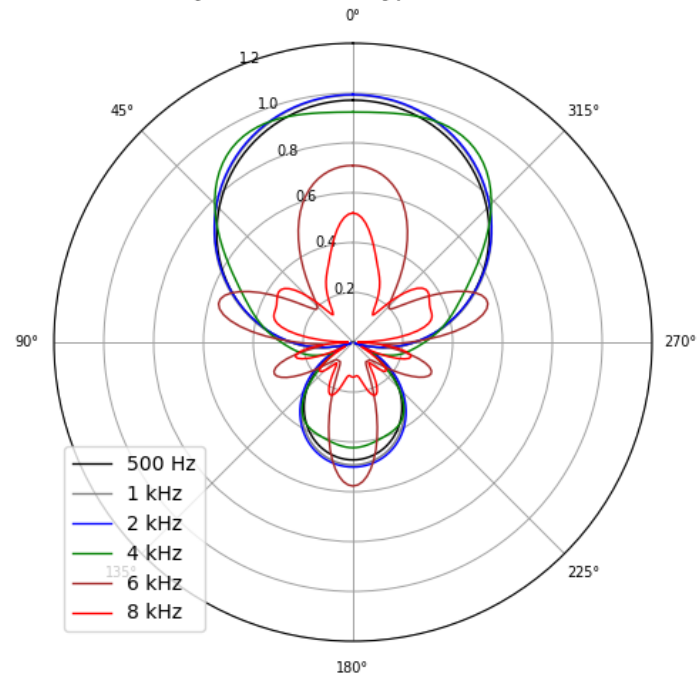
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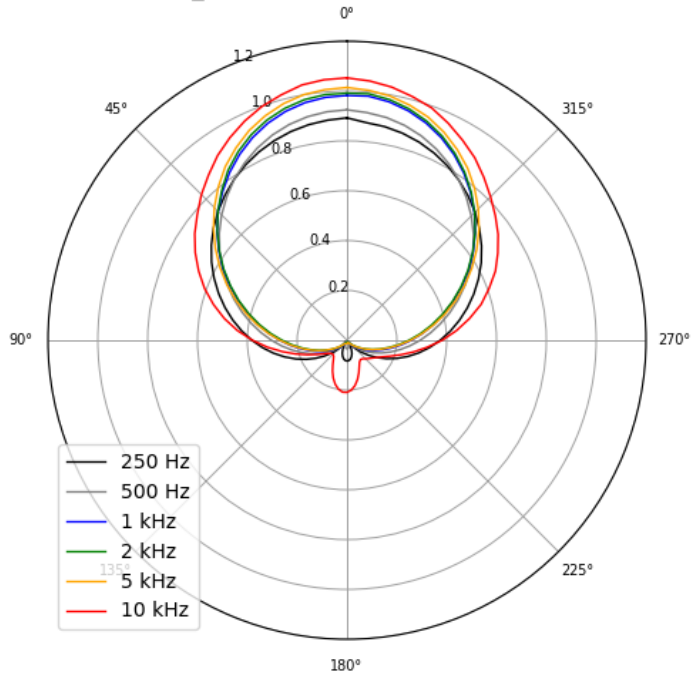
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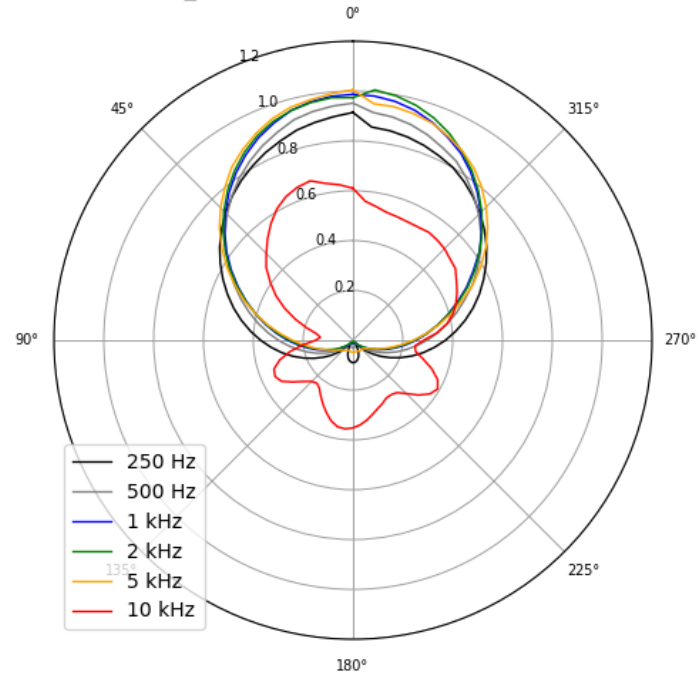
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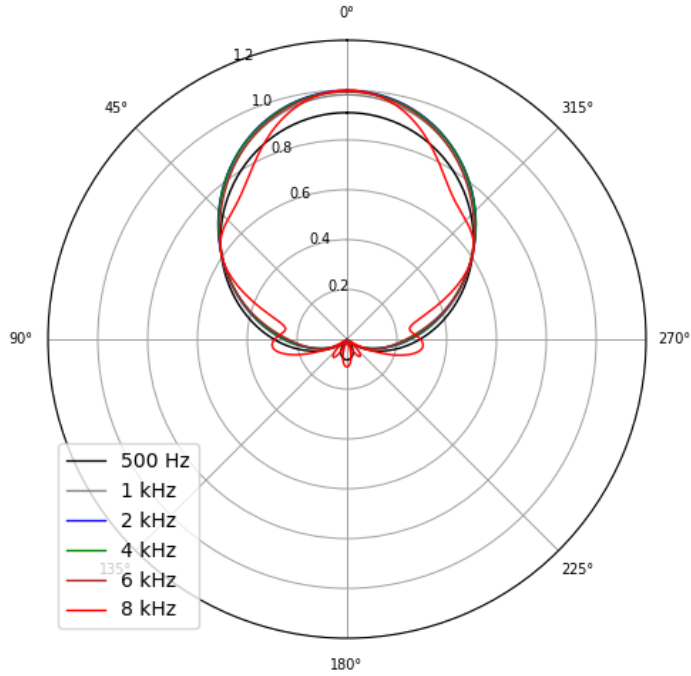
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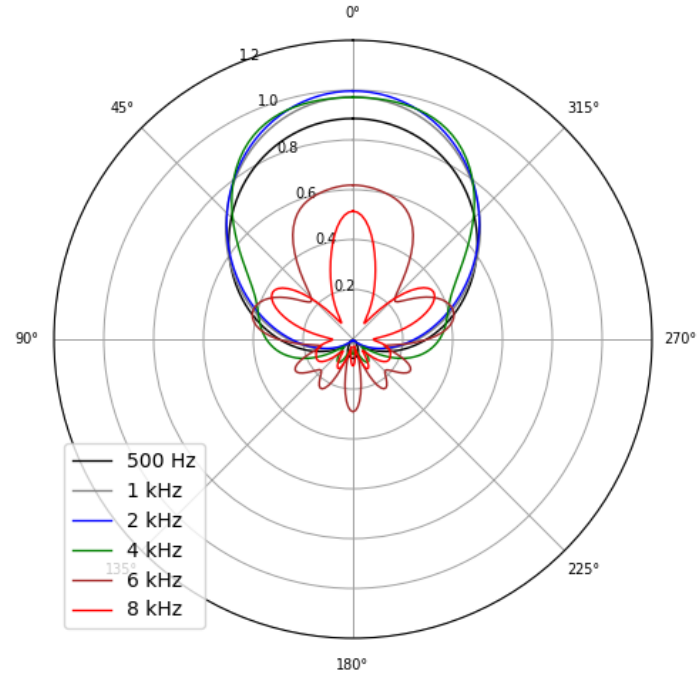
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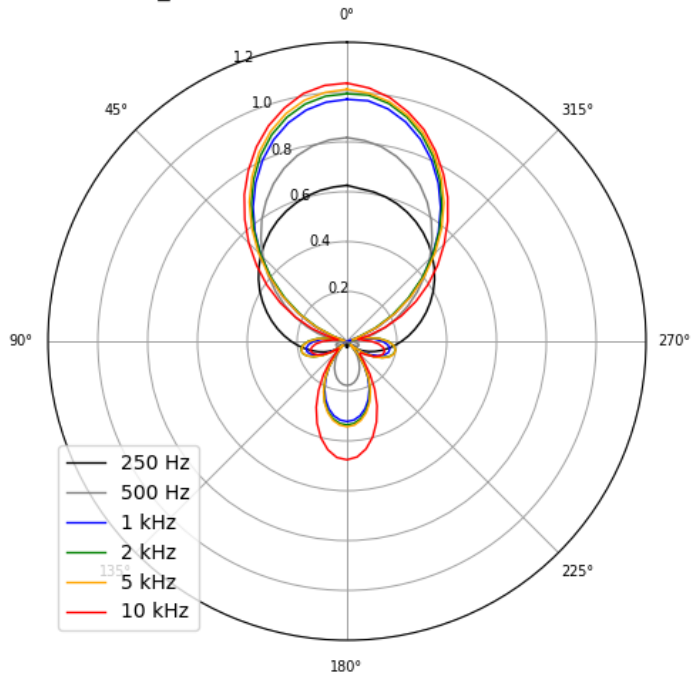
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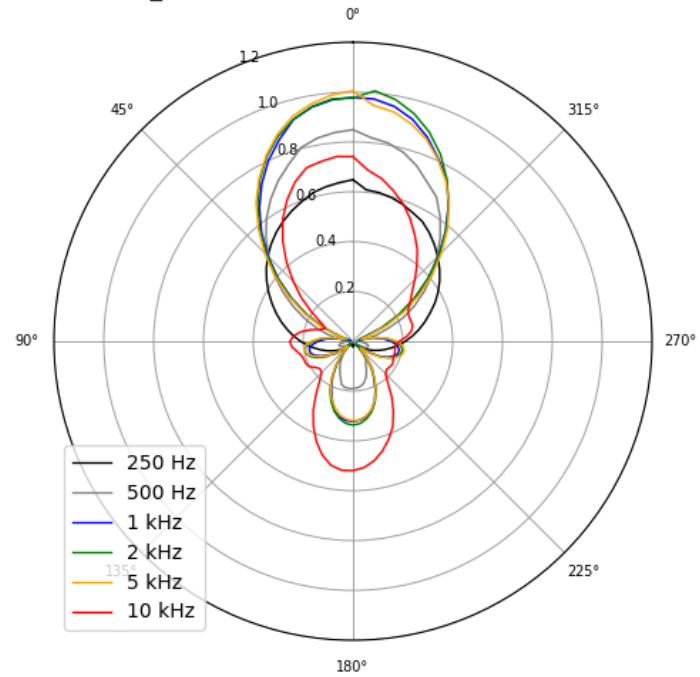
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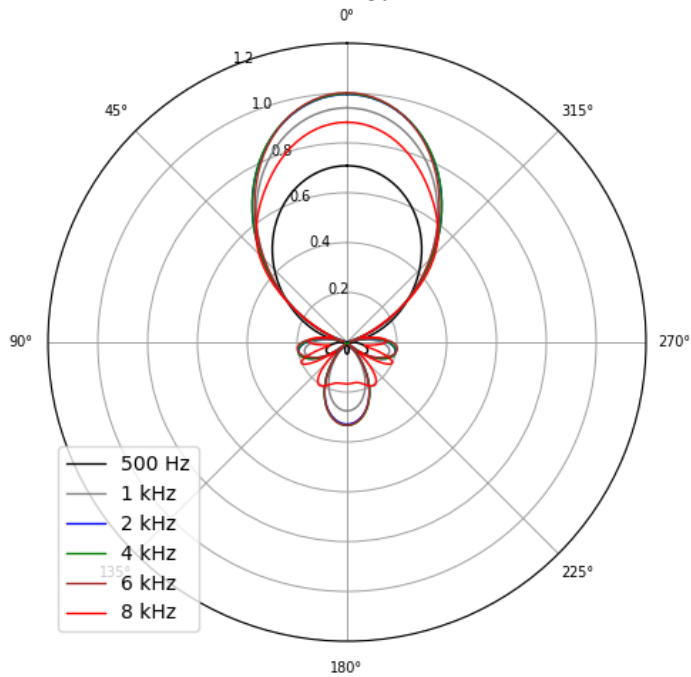
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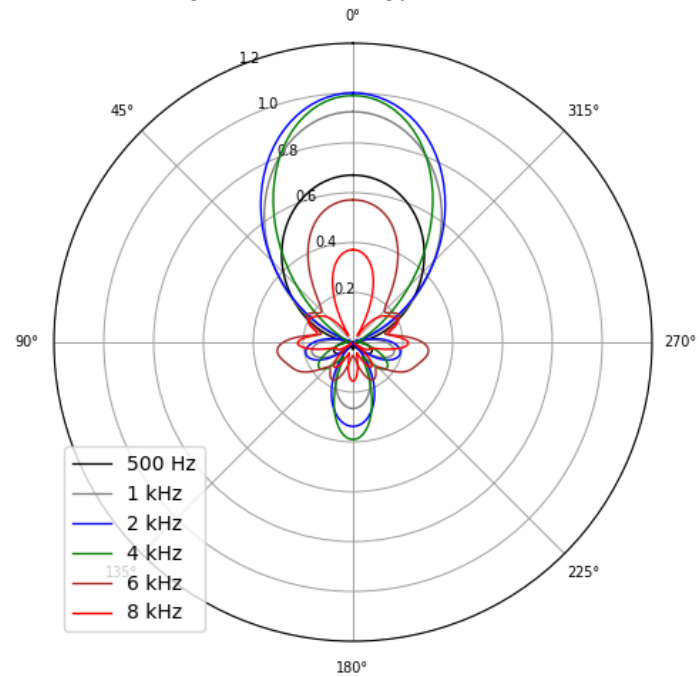
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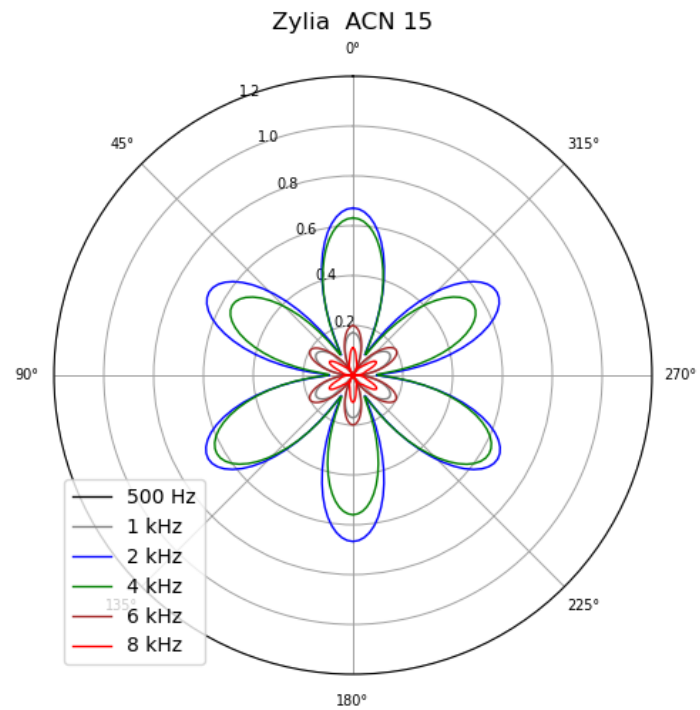
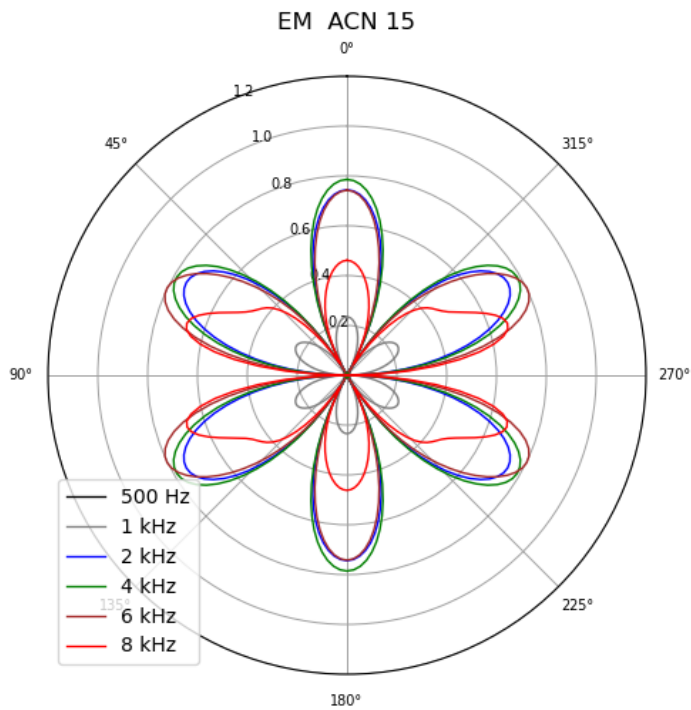
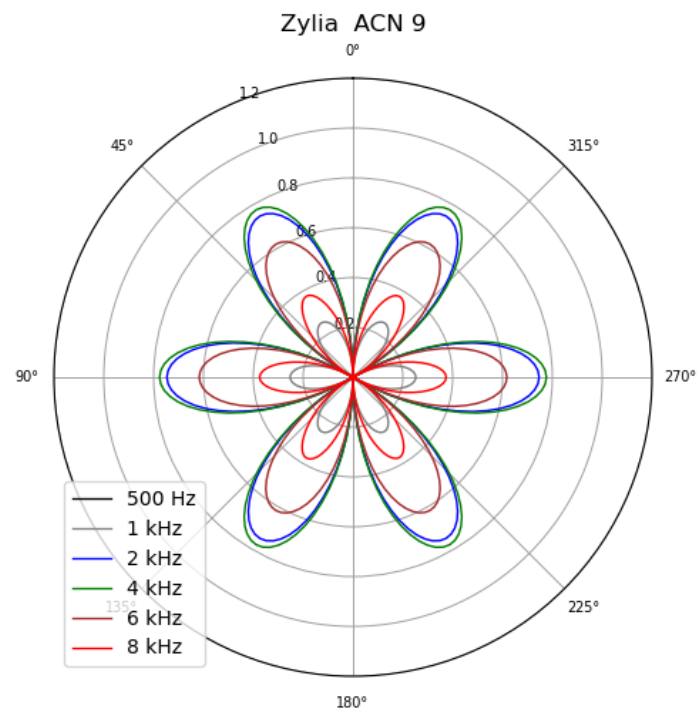
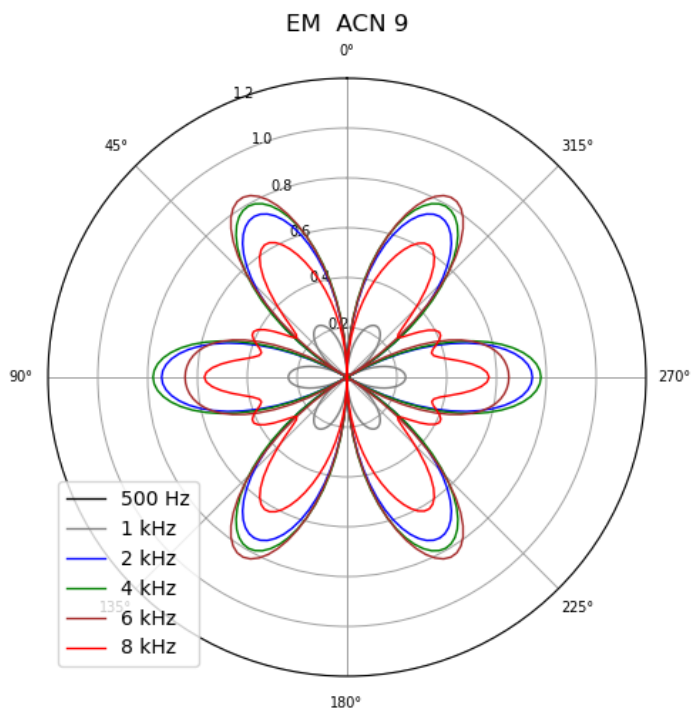


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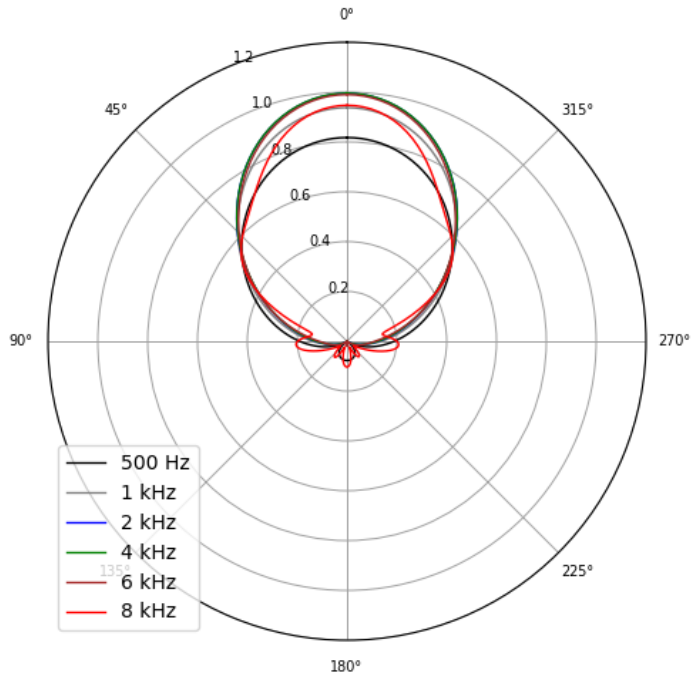


Zylia 2nd order hypercardioid

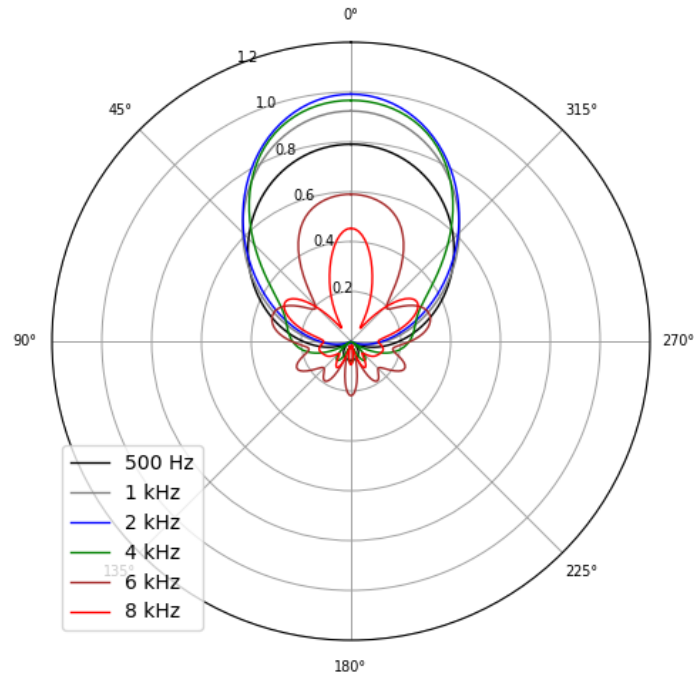




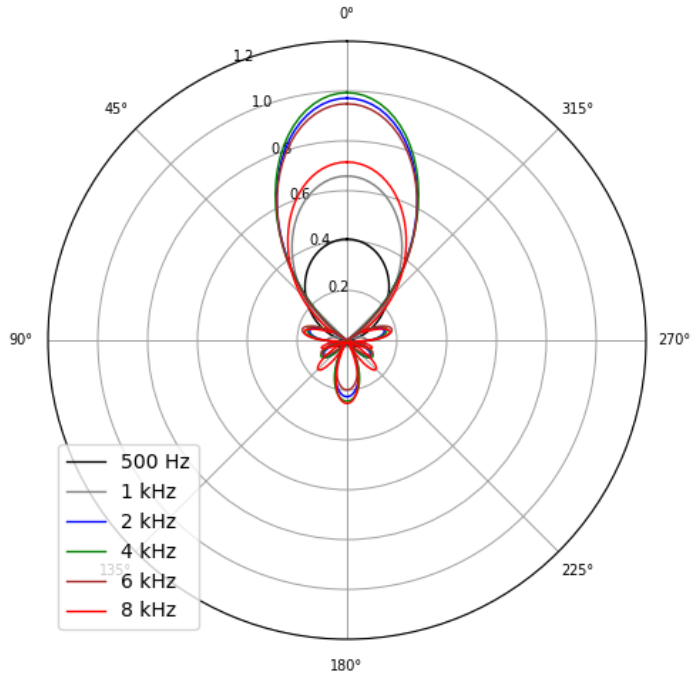
EM 3rd order cardioid



Zylia 3rd order cardioid



EM 3rd order hypercardioid



Zylia 3rd order hypercardioid

