*Technical Note*

Princeton Applied Research

AMETEK

**Subject: Noise Mitigation Using a Faraday Cage**

## Introduction

Environmental noise from power lines, surrounding equipment and instruments, lighting, HVAC systems, etc. are present in all laboratory environments. Whether or not this noise has a significant impact on the data being generated depends on the sensitivity of the experiment. In electrochemical analysis, low current and/or high frequency experiments are especially susceptible to the interference of environmental noise. There are a variety of noise mitigation techniques that can be implemented before, during and after data is acquired. These range from reducing environmental noise at the source (i.e. powering off nearby equipment) to applying hardware filters located within the potentiostat.

One of the most effective methods is the use of a Faraday Cage. A Faraday Cage is simply a metallic conductor in the form of a metal sheet or fine wire mesh that surrounds the electrochemical cell and the connections to the cell cable.[1] Michael Faraday invented the Faraday Cage in 1836, discovering that the charge on a continuous conductor will not impact its interior. Meaning, a Faraday Cage acts to shield anything housed in the cage from the effects of external electric fields.[2] All electrochemical experiments can benefit from the noise reducing properties of a Faraday Cage. However, the examples presented below highlight the significant impact on low current measurements.

## Examples

All experiments were run using a PARSTAT MC 1000 (PMC-1000), a Pt counter electrode and Ag/AgCl reference electrode in a solution of 1 mM $K_3[Fe(CN)_6]$ in 0.1 M KCl. The first example, shown in Fig. 1, compares cyclic voltammetry of a Pt micro electrode (25 $\mu$m diameter) outside (blue) and inside (red) of a Faraday Cage at 10 mV/s. Note that the black lead was connected to the Faraday Cage so that the Faraday Cage and the potentiostat are held at the same ground. Clearly the noise level in the raw current response was substantially reduced by the Faraday Cage. The second example, shown in Fig. 2, compares cyclic voltammetry of a Au milli electrode (2 mm diameter) outside (blue) and inside (red) of a Faraday Cage at 10 mV/s. In this example, the Faraday Cage still reduces the noise producing a smoother current response; however, it is evident that it is less valuable in this experiment. The current response in Fig. 1 is on the order of nanoamps, while it is on the order of microamps in Fig. 2, but it would be misguided to conclude that a Faraday Cage is only required for currents at the nanoamp level and below. The need for a Faraday Cage depends on the amount and frequency of environmental noise, which can vary with time, the degree of accuracy and precision required, as well as the current level and/or frequency of the response.

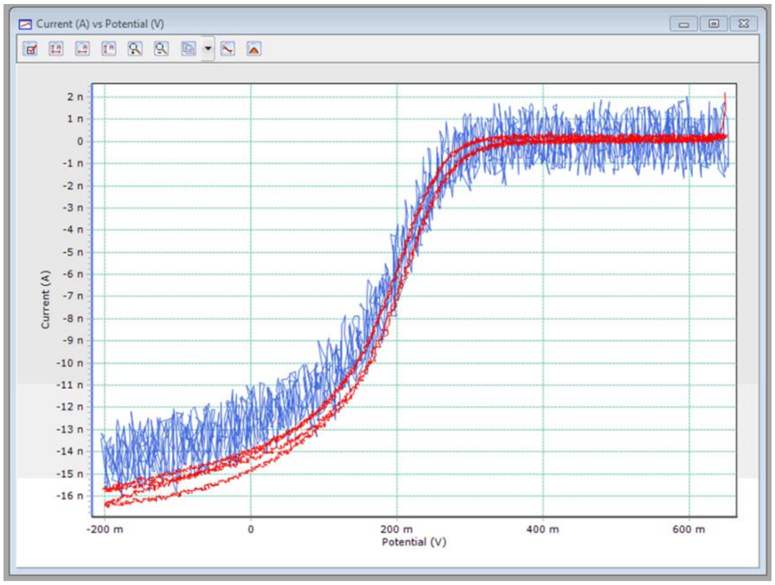


**Figure 1: CVs of Pt (25 μm diameter) outside (blue) and inside (red) of a Faraday Cage.**

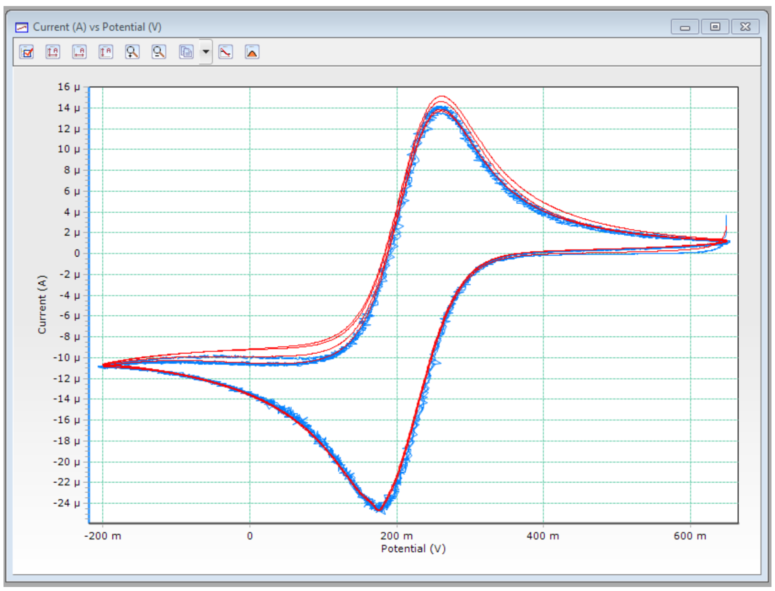


**Figure 2: CVs of Au (2 mm diameter) outside (blue) and inside (red) of a Faraday Cage.**

## Summary

A Faraday Cage is one of the many tools available to the researcher to ensure the highest quality of results and as such, should always be considered when noise interference is observed. Princeton Applied Research offers two options (VS-Faraday and K0269B) to accommodate different cell configurations and sizes.

## References

1. Orazem, M. and Tribollet, B. *Electrochemical Impedance Spectroscopy*, The ECS Series of Texts and Monographs, John Wiley & Sons, 2011.
2. Hirhfeld, A. *The Electric Life of Michael Faraday*, Bloomsbury Publishing, 2009.