BASi

# Tech Notes

## Low Current Measurements with EC Epsilon Electrochemistry Instrument

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BASi has been manufacturing electrochemical instrumentation to measure very small current with low noise for over 30 years. This instrument design knowledge was used to the fullest with the production of the BASi EC epsilon (e2). The e2 epsilon is easily capable of accurately measuring current down to 10 pA. The current resolution for most techniques is 31 fA and is determined by the highest gain range (+/-1 nA full scale) and the number of bits of the analog-to-digital converter (16 bit - 65,536 elements). With some techniques (DC Potential Amperometry and Controlled Potential Electrolysis) each point is an average of multiple samples which allows an effective resolution of 20 bits or 2 fA. However, noise rather than resolution specification usually determines the lowest current that can be accurately measured. The amount of noise is determined by the instrument's electronic design, good electrical power and grounding, amount of vibration, shielding of the cell, time scale of experiment (i.e., signal filtering) and other factors. Important design features of the e2 to minimize noise are component selection, circuit layout, and optical isolation between the circuitry's digital and analog components. Below are a few figures that show typical results with off-the-shelf e2 and C3 Cell Stand (Faraday Cage closed) on a normal lab bench. Note that raw data (i.e., no smoothing) is shown in the first four figures.

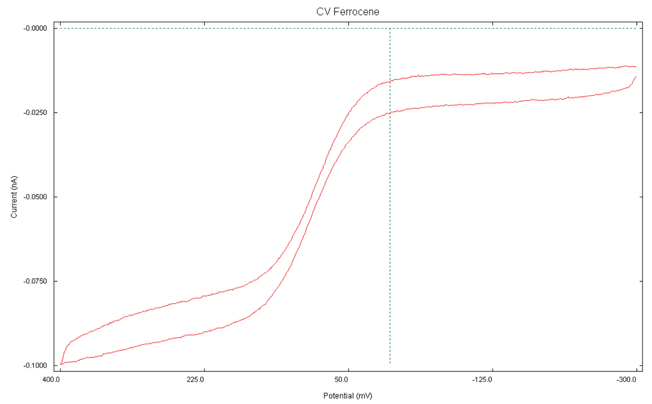


*Figure 2. Cyclic voltammogram of 10 uM Ferrocene in 0.1 M TBAP/Acetonitrile with a 10 um platinum electrode at a scan rate of 50 mV/s. The data is raw with no post-run smoothing. This voltammetric run uses a much lower analyte concentration so the current is reduced to a magnitude where the instrument is pushed to its highest gain range. Note that the limiting current is less than 100 pA and the noise is negligible. At the most sensitive current range an offset of 10s of pA is common.*

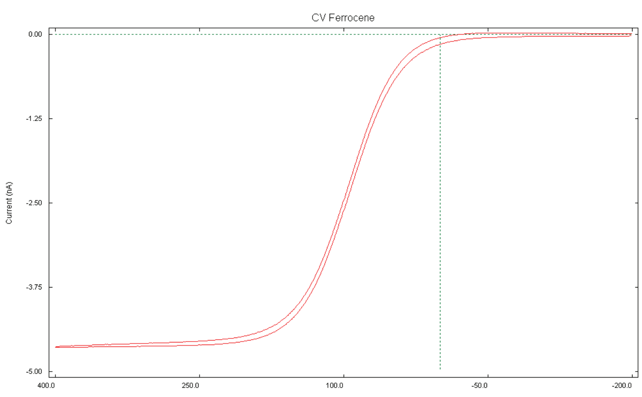


*Figure 1. Cyclic voltammogram of 1 mM Ferrocene in 0.1 M TBAP/Acetonitrile with a 10 um platinum electrode at a scan rate of 50 mV/s. This is raw data with no post-run smoothing. This is a typical voltammogram obtained with the most common size microelectrode and concentration of analyte which, in turn, gives a current in the 1-10 nA range.*

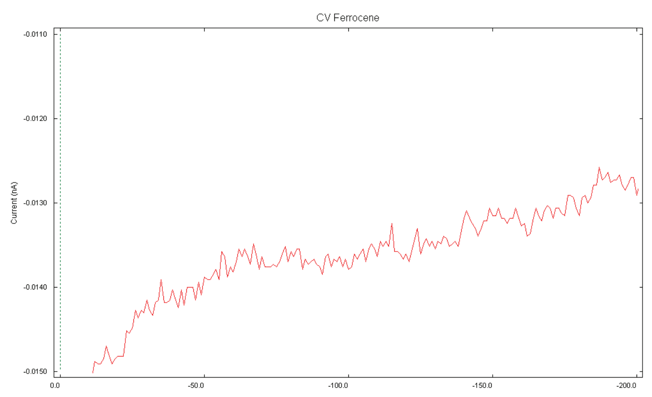


*Figure 3. Expanded scale of data in Figure 2 to demonstrate noise in raw data. Note that each division of Y-axis is 1 pA.*

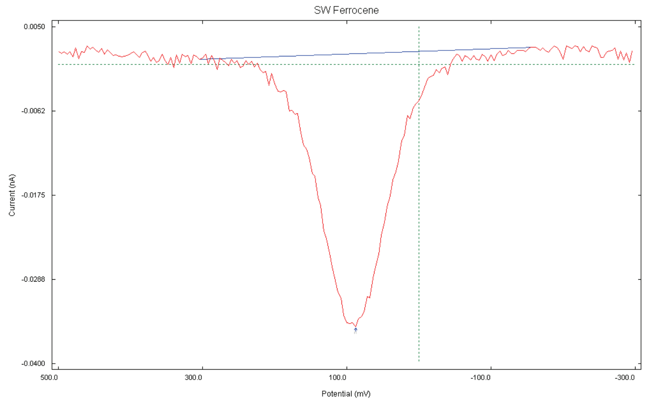


*Figure 4. Squarewave voltammogram of 10 uM Ferrocene in 0.1 M TBAP/Acetonitrile with a 10 um platinum electrode at a frequency of 15 Hz. This is raw data with no post run smoothing. Normally, smoothing is performed after the run to reduce noise and give a more reproducible peak measurement. The peak height is 36 pA.*

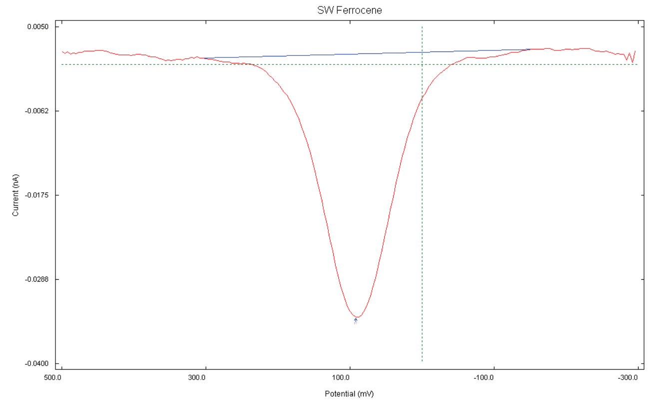


*Figure 5. Same data as shown in Figure 4 after a 9-point Moving-Average Smooth.*