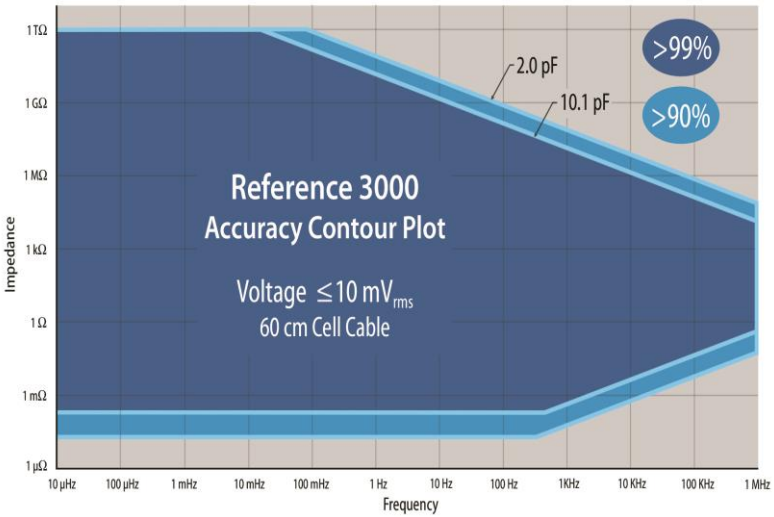
Electrochemical Impedance Spectroscopy: Quick Check of System Accuracy

Gamry Instruments

EIS: Accuracy Contour Plot vs. Quick Check

- A complete ACP shows total, normal system performance (see right)
  - Generally collected using normal operating parameters (e.g. 10 mV potentiostatic EIS)
  - May also be optimized for each point/region
  - Takes a long time to measure and determine
  - (Open and Shorted Lead EIS spectra are *Not* the ACP)



- EIS Quick Check:
  - Simple test that will work across platforms
  - Gives a rough check of system performance
  - Establishes proper setup for making accurate measurements

How to Run an EIS Quick Check

- Run EIS on Some Precision Resistors
  - Potentiostatic, 10 mV AC
  - 100 Ω 1 kΩ and 10 kΩ
  - Shows Real System Response
- Run Shorted Lead EIS
  - Galvanostatic, 100-400 mA AC
  - Shows Low Impedance Ability
  - Measure of Cable Inductance
- [Optional] Run an Open Lead EIS
  - Potentiostatic, 50 mV AC
  - Measure of Cable Capacitance, System Limit
  - Not Necessarily Useful for Accuracy

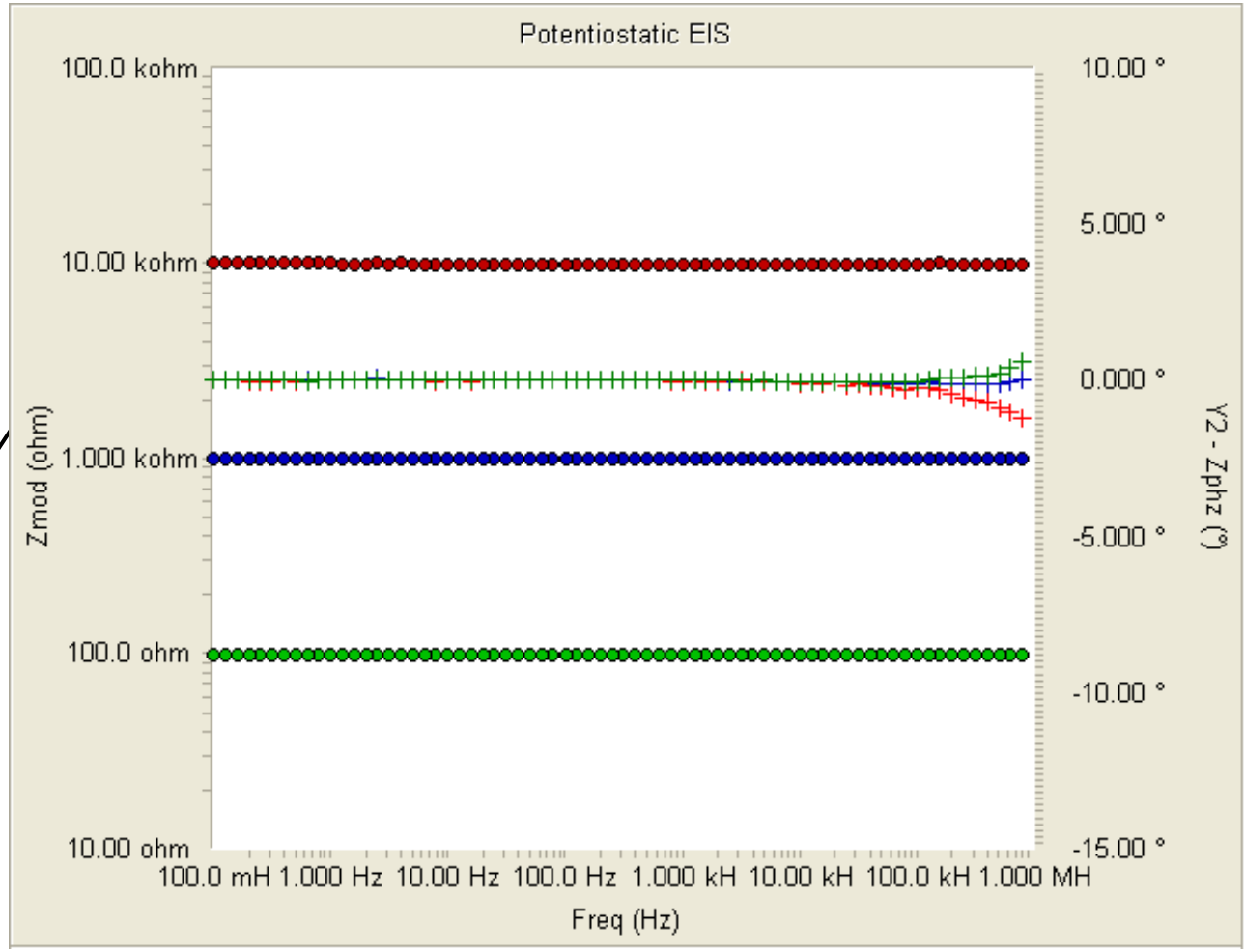
Cable Setup Matters

- For some impedance measures Cable positioning makes a big difference.
- 1 kΩ: Any should work
- 100 Ω and Shorted: minimize inductance by twisting cables (current pair together from one side, sense pair together from the other)
- 10 kΩ and Open: minimize capacitance by separating work leads from counter/ref leads as much as possible
  - (for Open connect work to work sense and counter to reference, place working pair inside Faraday cage)

Good Resistor Response

- 100 Ω: Green
- 1 kΩ: Blue
- 10 kΩ: Red

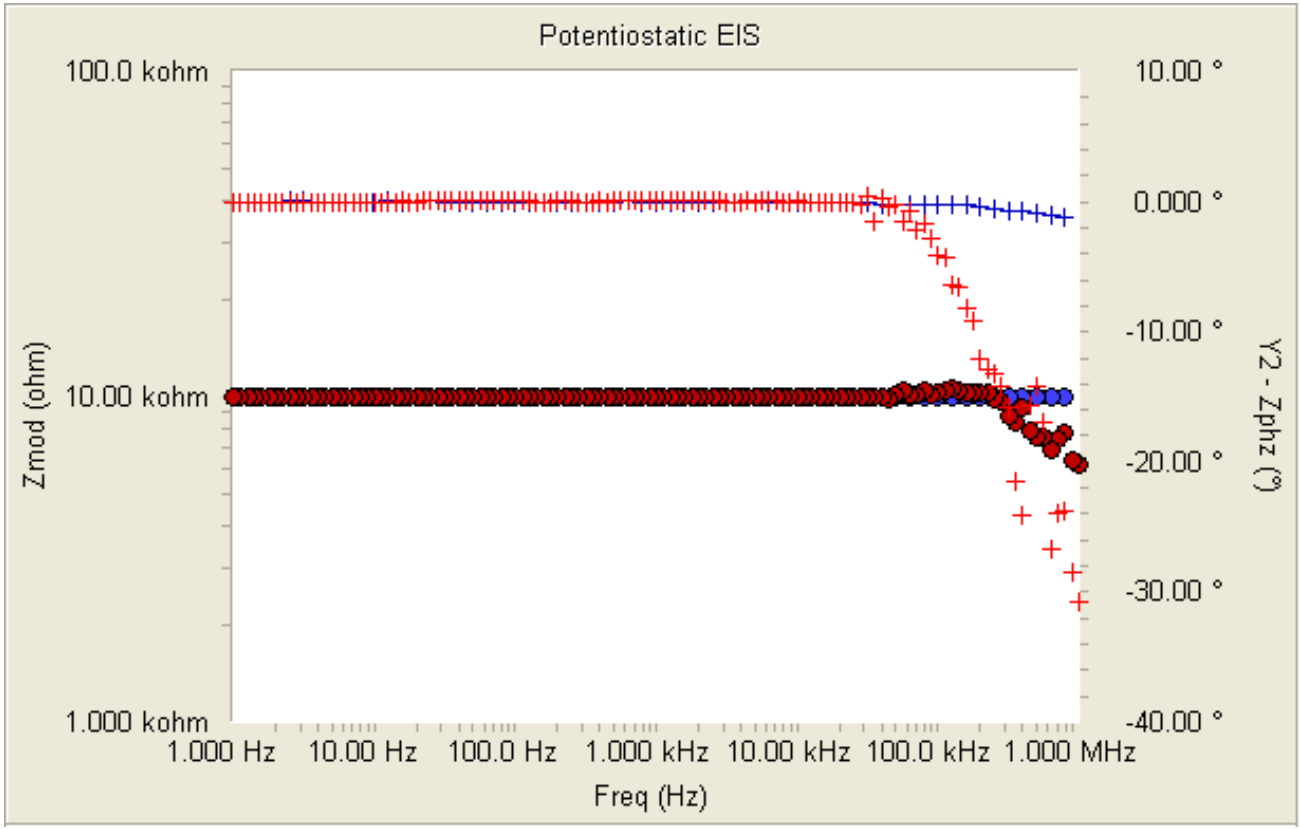
- Magnitude w/in 1%
- Phase w/in 2°
  - Down capacitive
  - Up Inductive



Bad Resistor Response

- Gamry: Blue
- *Other*: Red

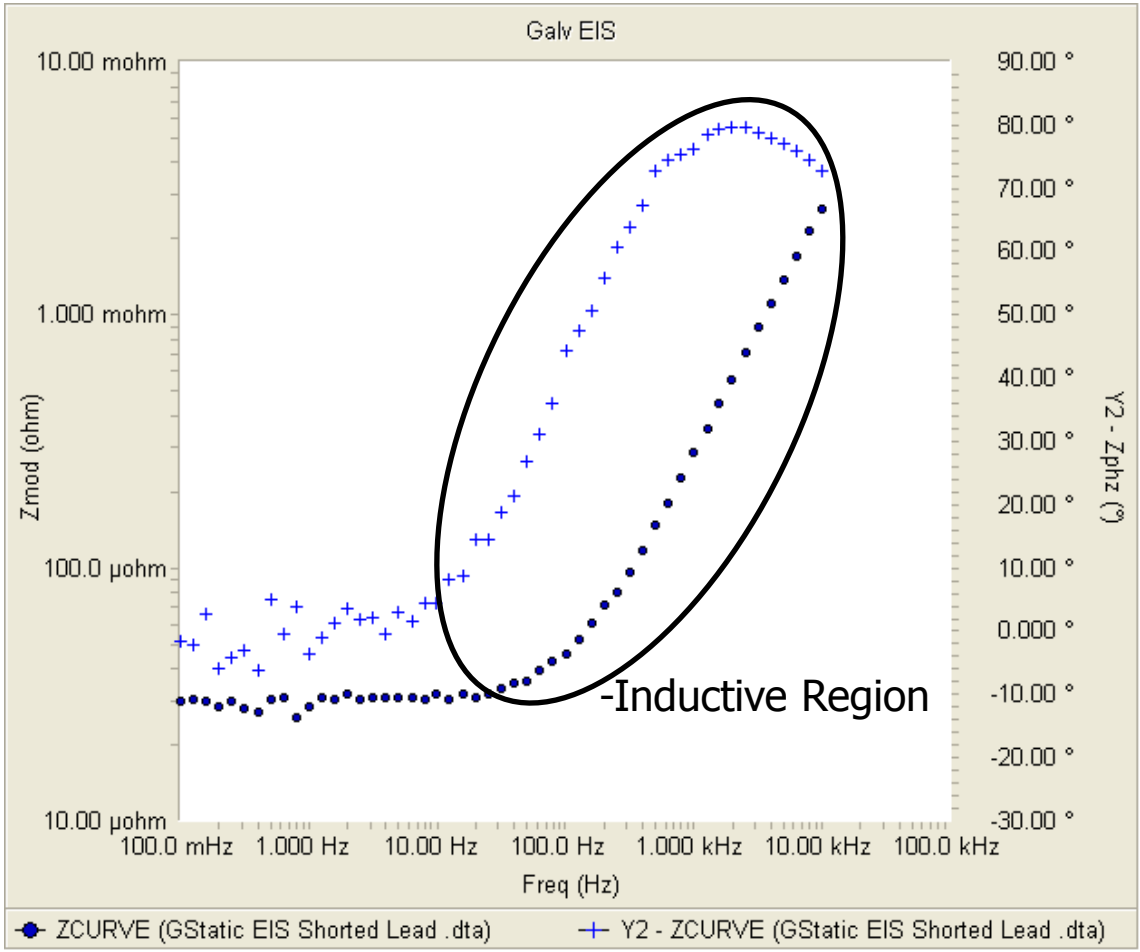
- *Other* 1 MHz System
  - 40% Error in Z
  - 30° Phase Error
  - System only accurate to ~50 kHz



Shorted Lead Curve

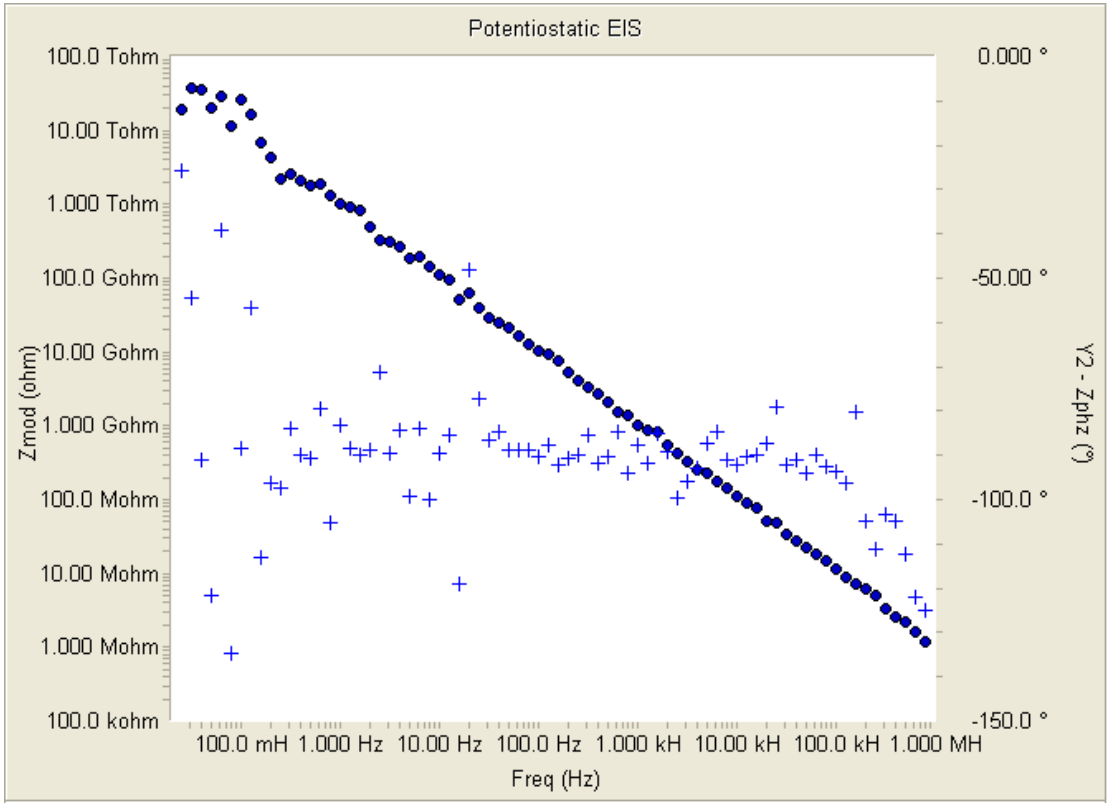
- Very small resistor
- Inductance will be present at higher f

- Note:
  - Calculated resistance of copper braid is 10 μΩ per mm, with 2-3 mm between leads (or about the measured 30 μΩ)



Open Lead Curve

- Should look like a capacitor
  - 90° phase
  - Capacitance based on cabling
  - Low f rolloff may be present on less sensitive systems



Quick Check Take Home

- Instruments have limits
- Setup matters
- Know where your system lies
  - High Impedance (Coatings)
  - Low Impedance (Energy Devices)
  - Other…(Corrosion, Sensors)