# Capacitive Electric Field Sensors for Low-Conductivity Spectral-Resistivity Surveys

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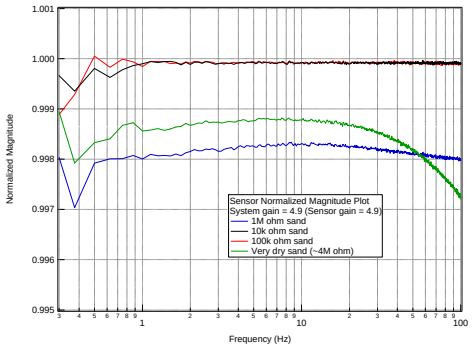
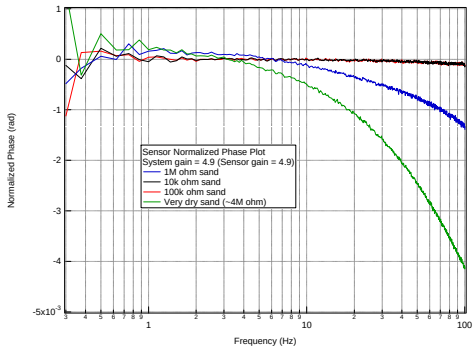
## Ultra High Impedance Capacitive Ground Electrodes

- Sensor placed on the ground surface
  - No burial, or preparation of mud
- Enables surveys over highly resistive ground: ultra dry, frozen, desert, resistive rock
- Sensing plate does not react chemically with the ground
  - No effect of ground water content, ground temperature
  - No degradation of contact over time
- Active cable drivers and triple twisted pair cable reduce noise pickup in signal lines and coupling to the ground
- 6-channel analog differencing unit (ADU) provides the true voltage difference output and power to all sensors
  - Data acquisition to be integrated into ADU in 2012

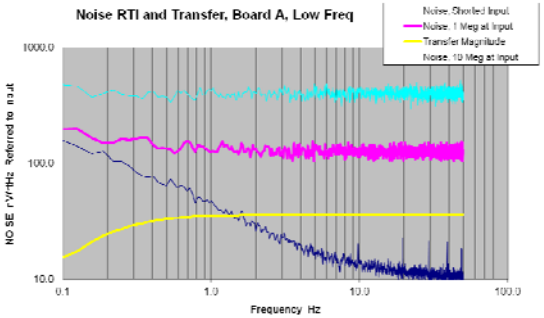
## Measurement Fidelity Robust to Changes in Ground Conductivity



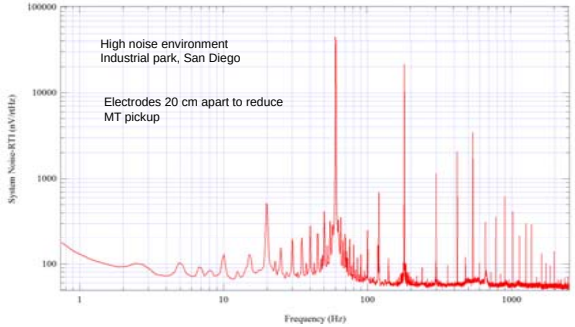

- Less than 0.05% change in gain and 0.1 mrad in phase from 0.3 to 100 Hz for changes in ground impedance from 1 Ohm to 100 kOhm (32 kΩm resistivity)
- Exceptionally flat gain and phase response up to 4 MΩ ground resistance

## Improved Sensitivity via Elimination of Electrochemical Interactions



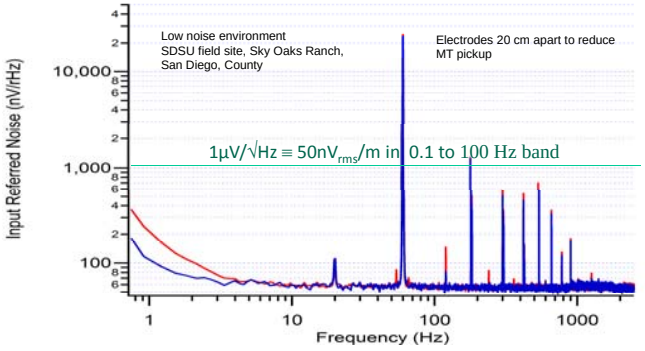

### Very low sensor internal noise

- 40 nV/√Hz at 1 Hz
- 10 nV/√Hz > 20 Hz




### Excellent system noise performance outdoors on dry ground (35 kΩ) in both low and high noise environments

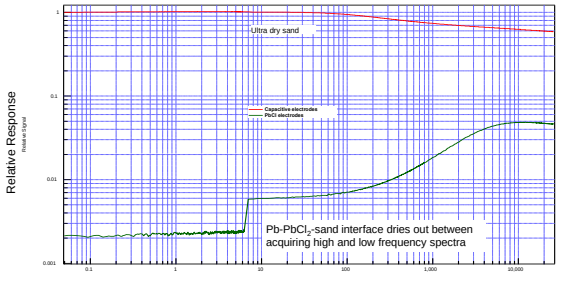
- ~ 120 nV/√Hz at 1 Hz
- 60 nV/√Hz > 10 Hz




### Data taken with 2 x 100 m cables

- E-field spectrum better than 1 nV/m/√Hz over entire band
- E-field sensitivity 3 nV$_{rms}$/m over band from 0.1 Hz to 100 Hz

## Conventional Electrodes Unable to Operate under Ultra Dry Ground Conditions




**Capacitive sensors able to operate on ultra dry sand (10 MΩm). Pb-PbCl$_2$ unable to establish a galvanic contact**

Testing continuing in collaboration with the Colorado School of Mines and Berkeley Geophysics Associates, Inc.