



# Distinguishing Induced Voltage vs Direct Contact Voltage - *EPRI Field Trial Research Update*

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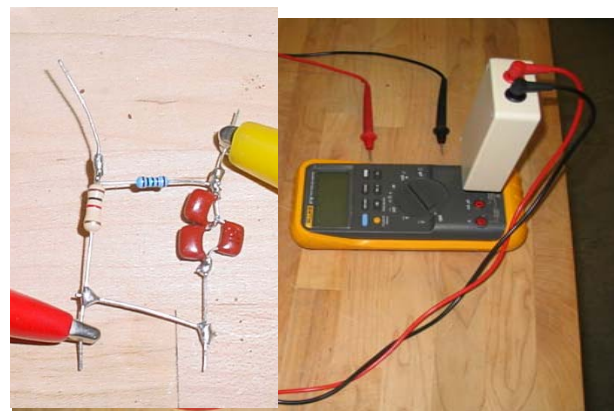
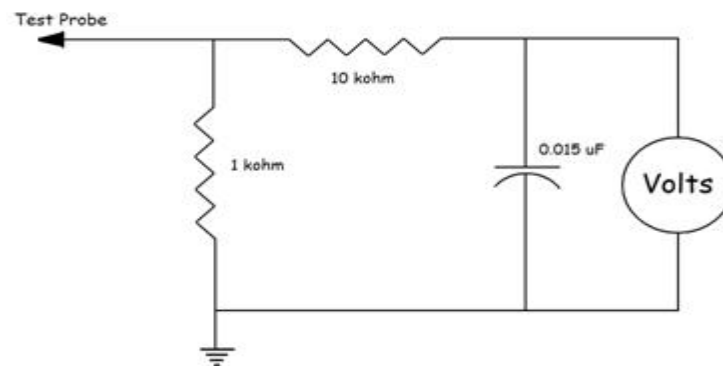
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# Question 1

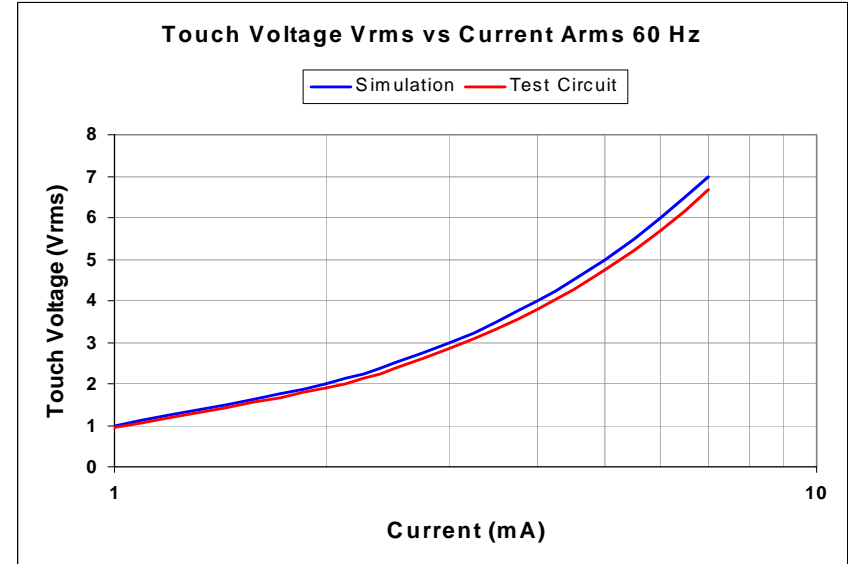
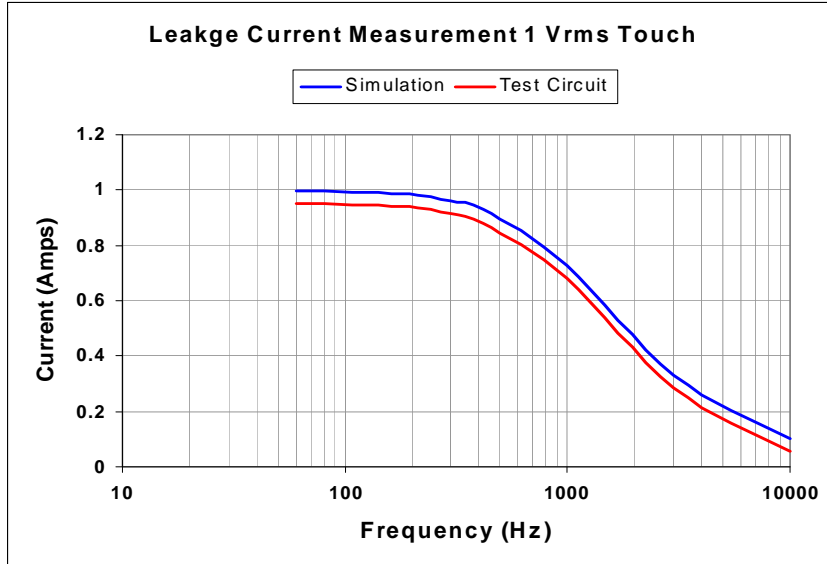
- How does the actual soil moisture and content impact voltage measurements during steady state fault conditions?

# Using Load Resistors - Generic Human Body Model

- Derived from IEC 60601-1
- Used as a known reference for measurements
- A simple 1 k ohm burden resistor would be sufficient
- Burden voltage varies with impedance of soil at the time of measurement



# Basic Human Model Characterization and Simulation



# Direct Contact Measurement

## ■ Wet and Dry Samples

- Sample 1
  - 50% Clay
  - 25% Sand
  - 25% Salt
- Sample 2
  - 75% Sand
  - 25% Salt
- Sample 3
  - 50% Sand
  - 50% Salt
- Sample 4
  - 100% Sand

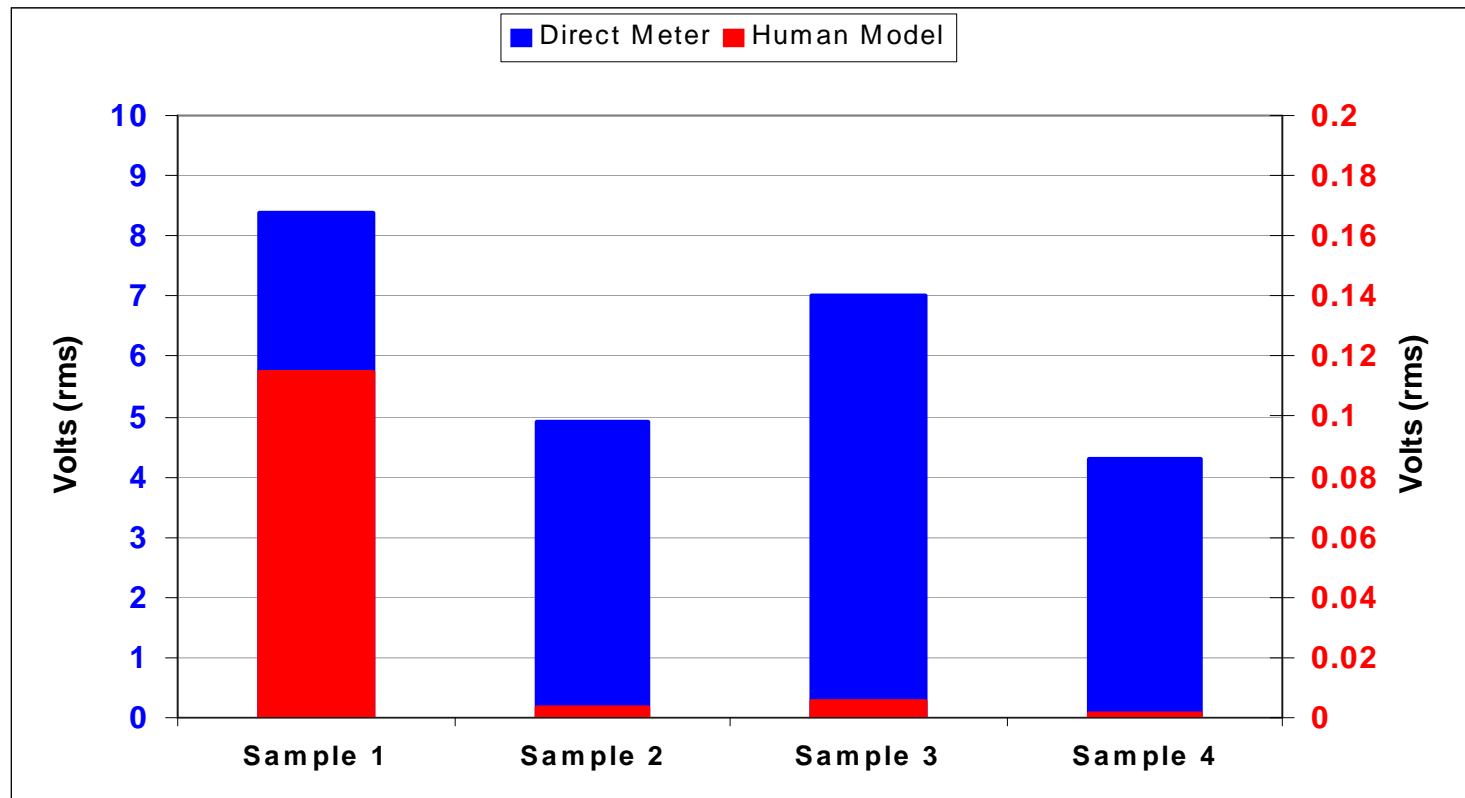


# Direct Contact Result



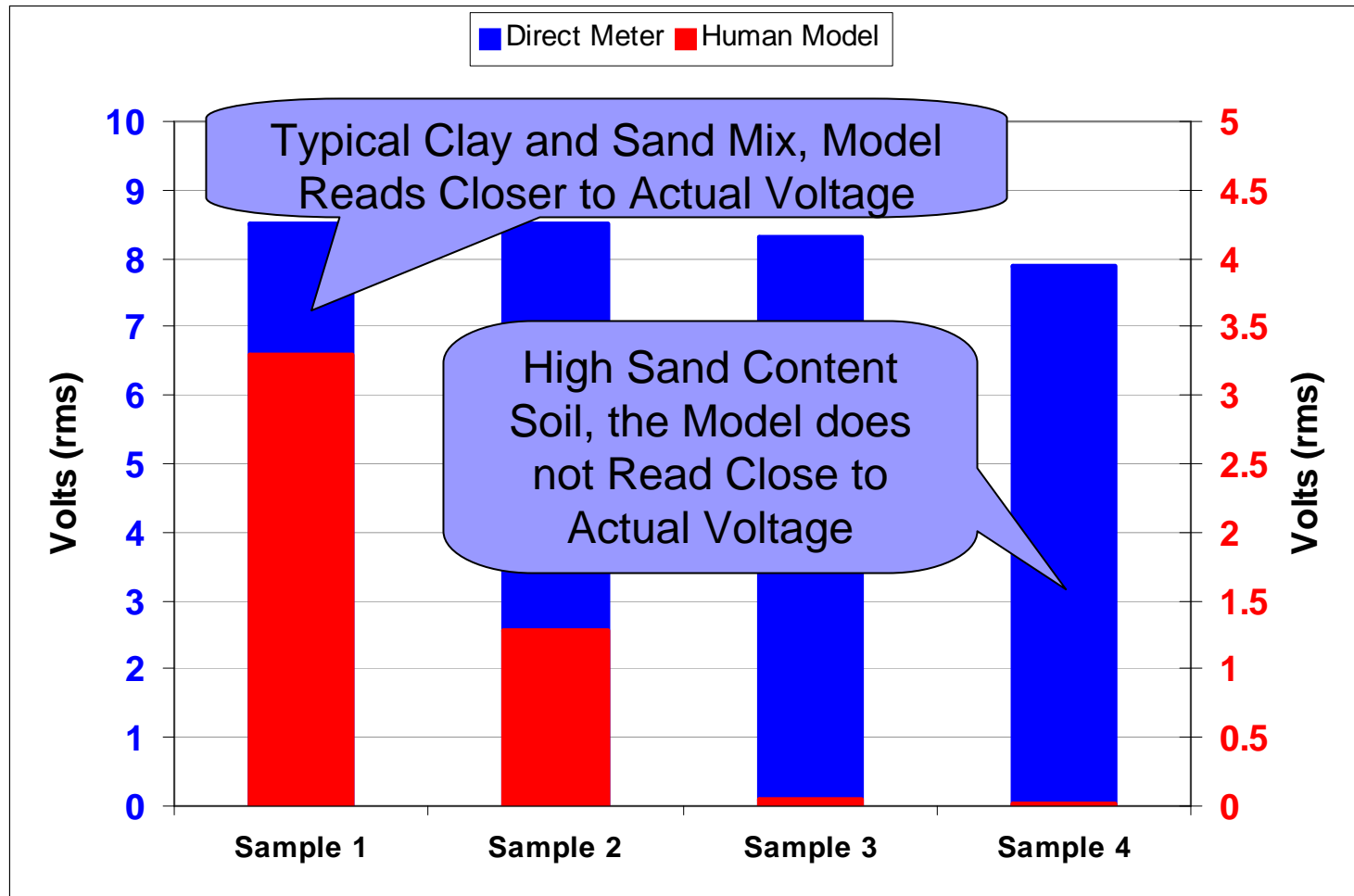
- Frequency was measured for direct contact with four different soil, and salt mixtures
- In all cases where the voltage was of sufficient amplitude where the meter could read the frequency, the result was 60 or  $\approx 60$  Hz

# Human Model Required Dry Samples



Sample 1 – (50% Clay 25% Sand 25% Salt) Sample 2 – (75% Sand 25% Salt) Sample 3 – (50% Sand 50% Salt) Sample 4 – (100% Sand)

# Human Model Should be Used or 1 k ohm Resistor Wet Samples



Sample 1 – (50% Clay 25% Sand 25% Salt) Sample 2 – (75% Sand 25% Salt) Sample 3 – (50% Sand 50% Salt) Sample 4 – (100% Sand)



# Dry vs Wet with Human Model

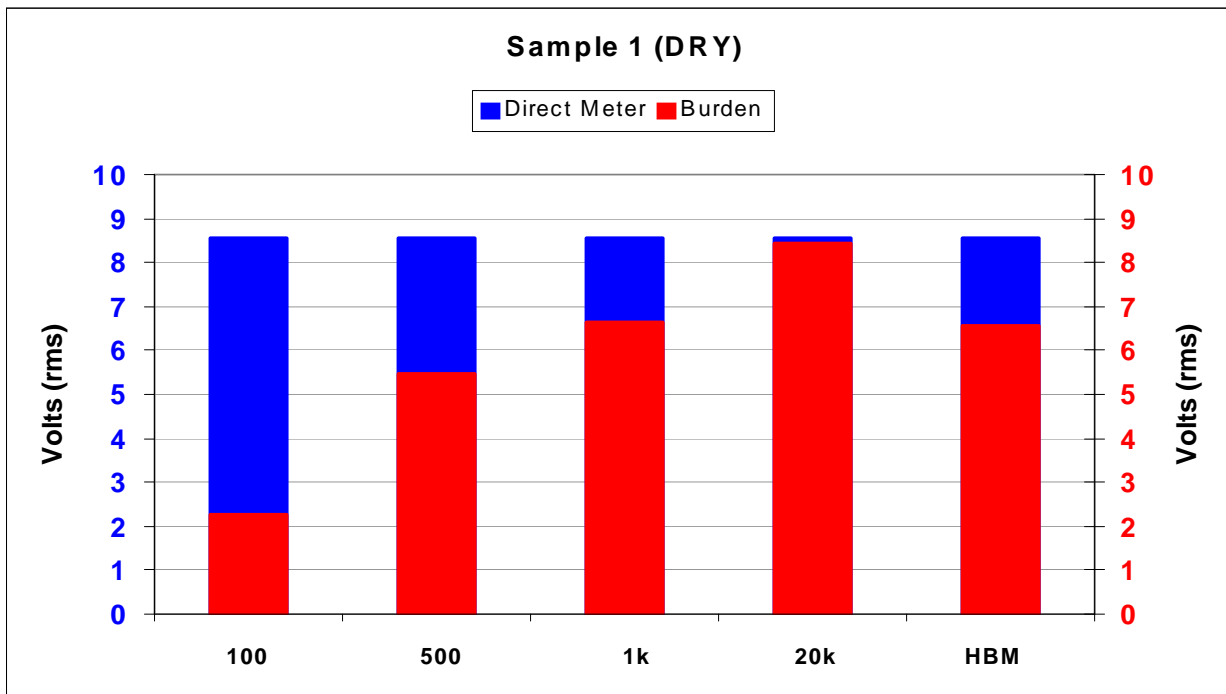
- When the soil is highly conductive with salt or moisture - the voltage measured with the Human Model may be close to the actual fault voltage
- When the soil is a poor conductor (or dry) the actual fault voltage reading may be very very low - but if 60 Hz is measured then it 'may represent' a fault condition

# Question 2

- How does the actual resistance value selected for the measurement impact the reading?

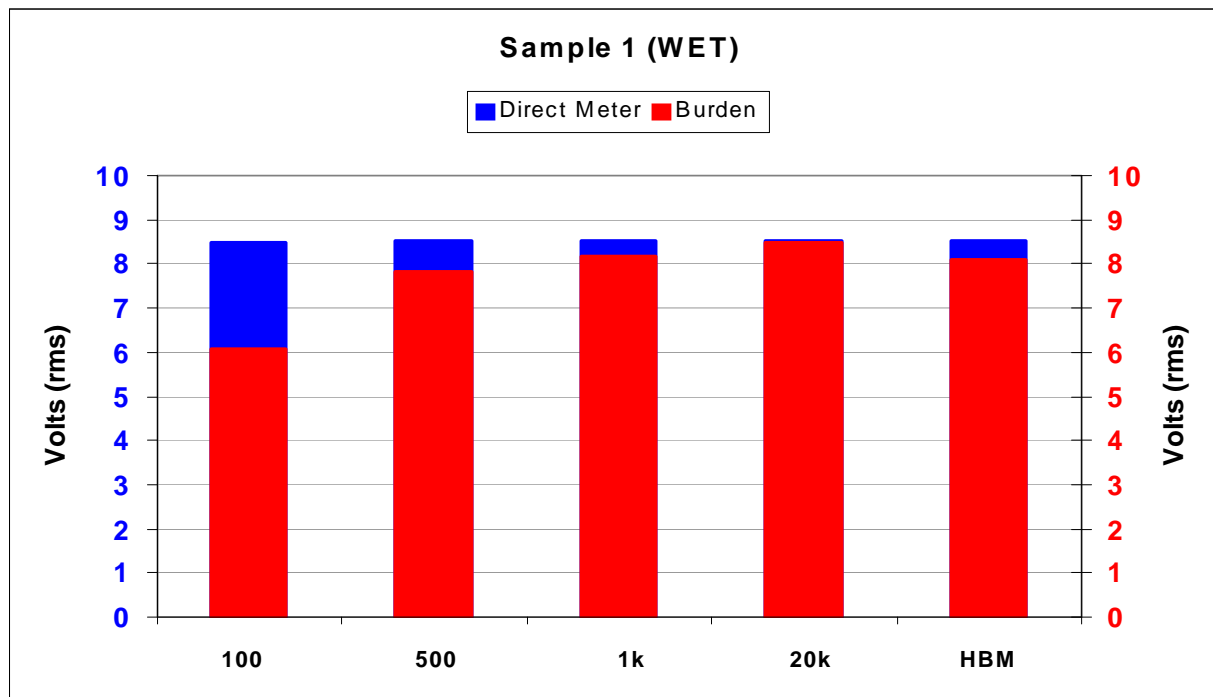
# Different Burden Resistance

Following Examples, Direct Meter is Source Voltage



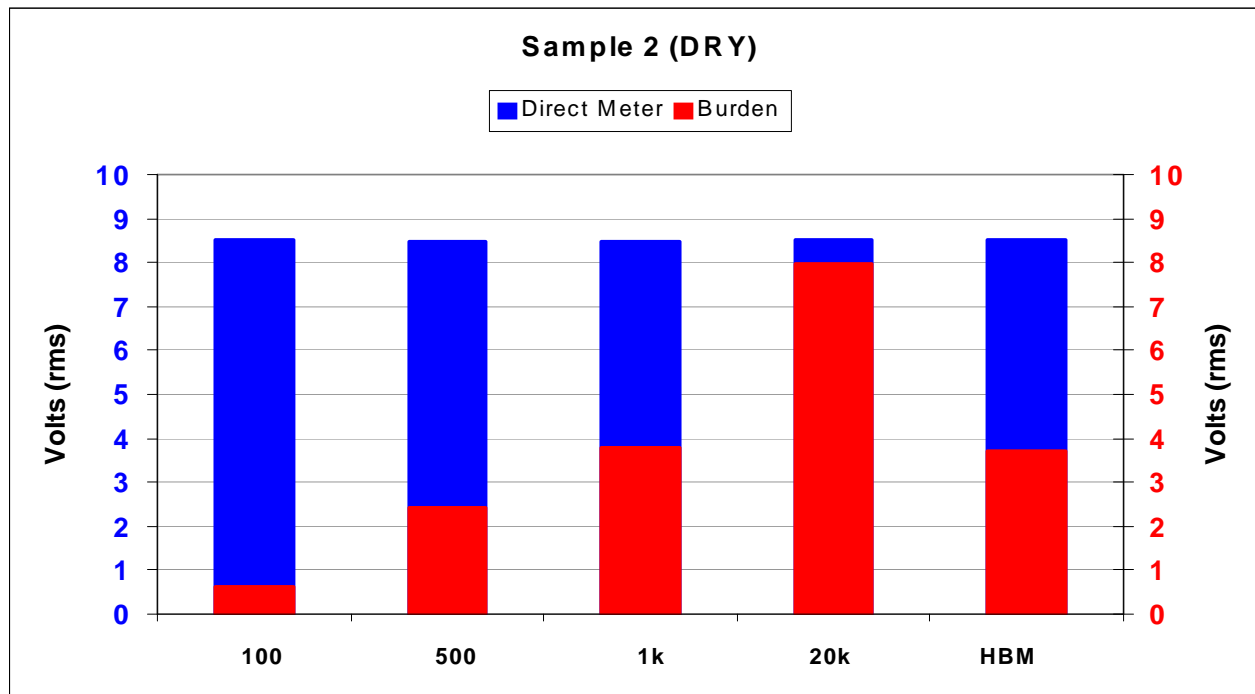
**Sample 1 – (50% Clay 25% Sand 25% Salt)**

# Different Burden Resistance



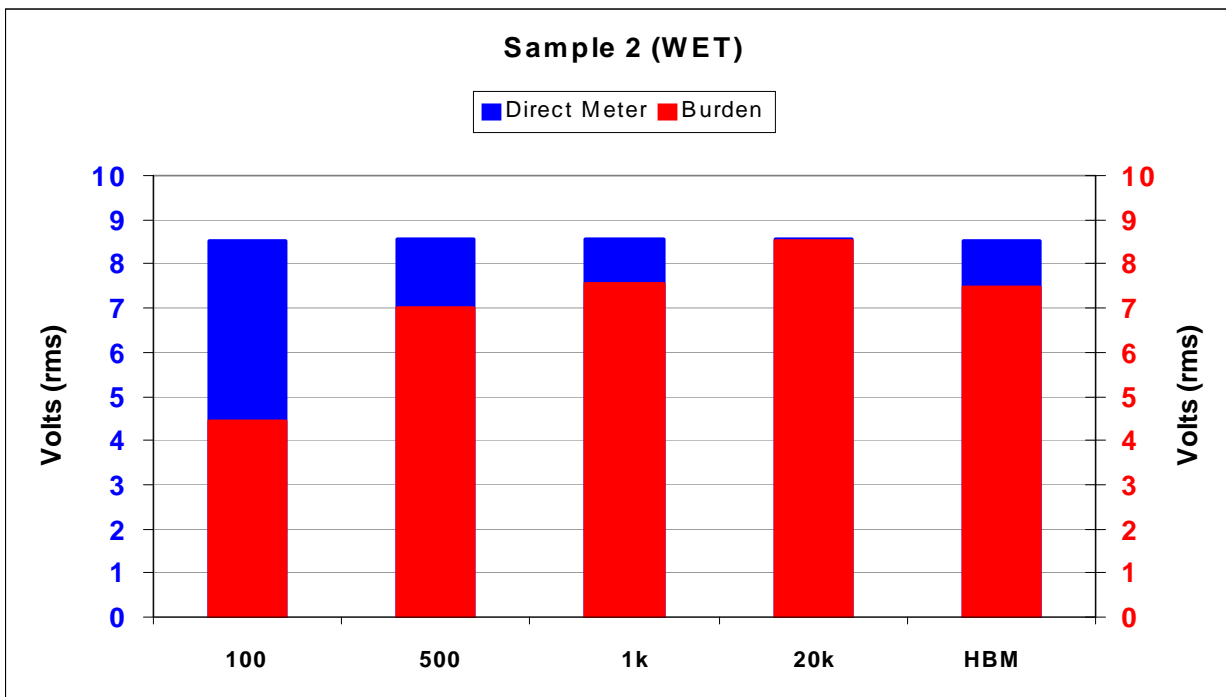
**Sample 1 – (50% Clay 25% Sand 25% Salt)**

# Different Burden Resistance



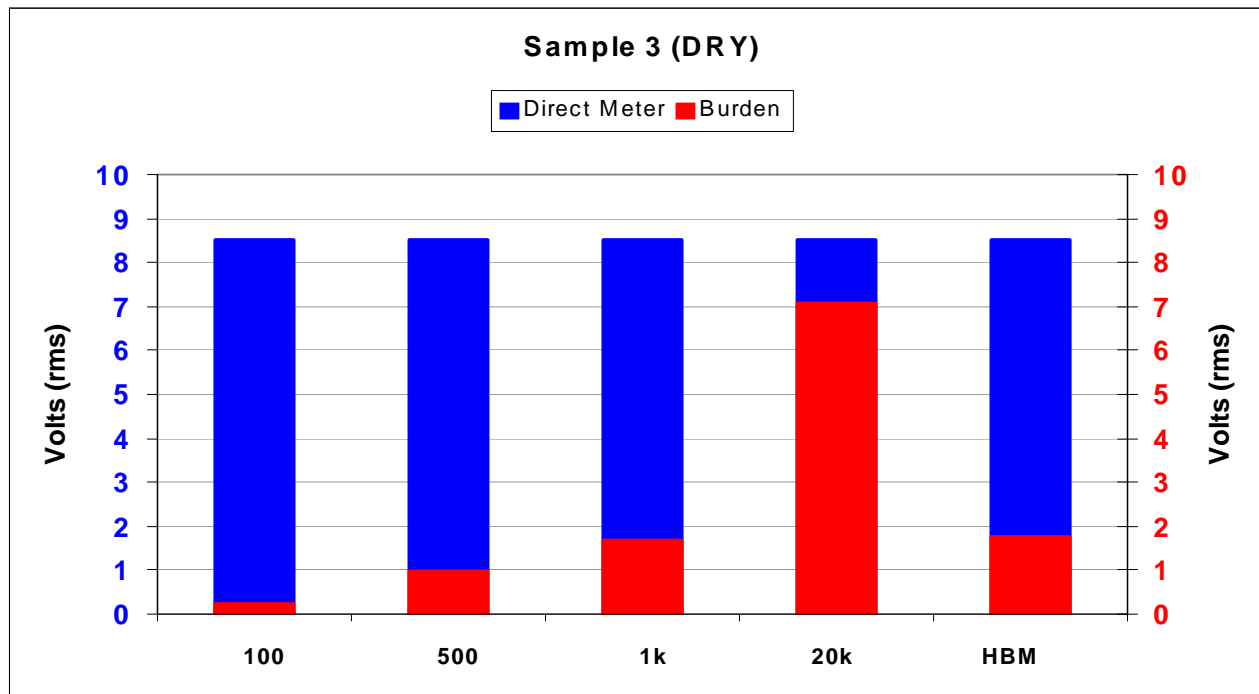
**Sample 2 – (75% Sand 25% Salt)**

# Different Burden Resistance



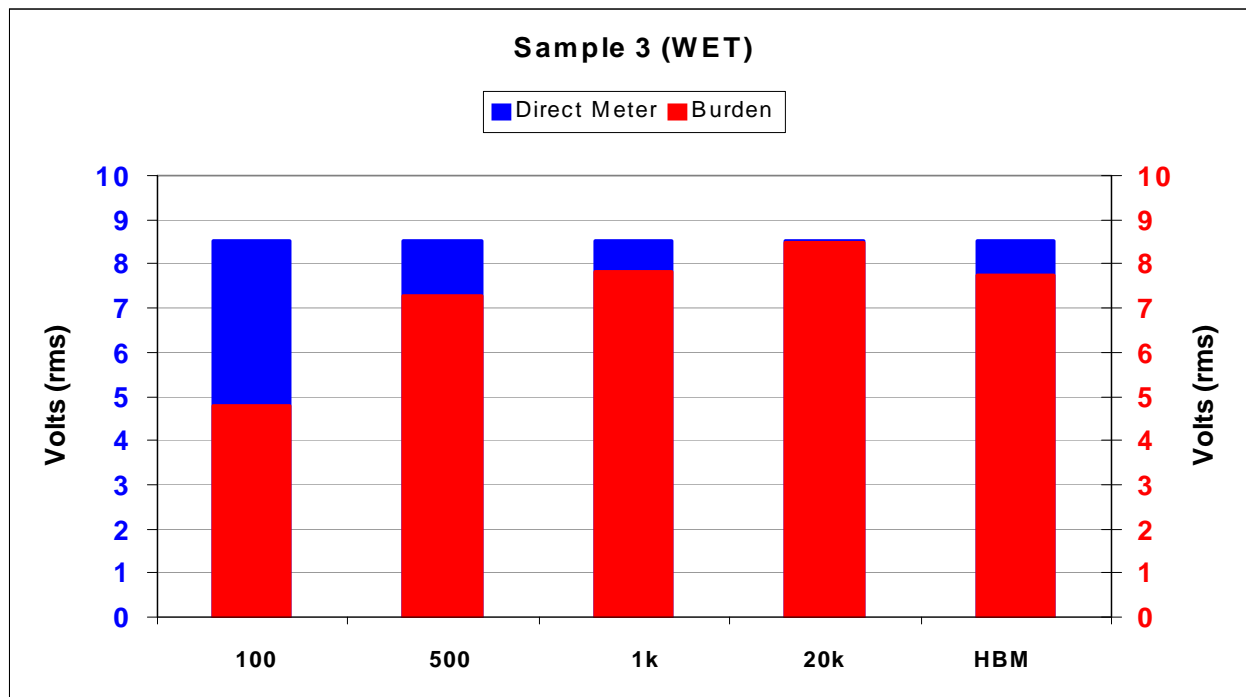
**Sample 2 – (75% Sand 25% Salt)**

# Different Burden Resistance



**Sample 3 – (50% Sand 50% Salt)**

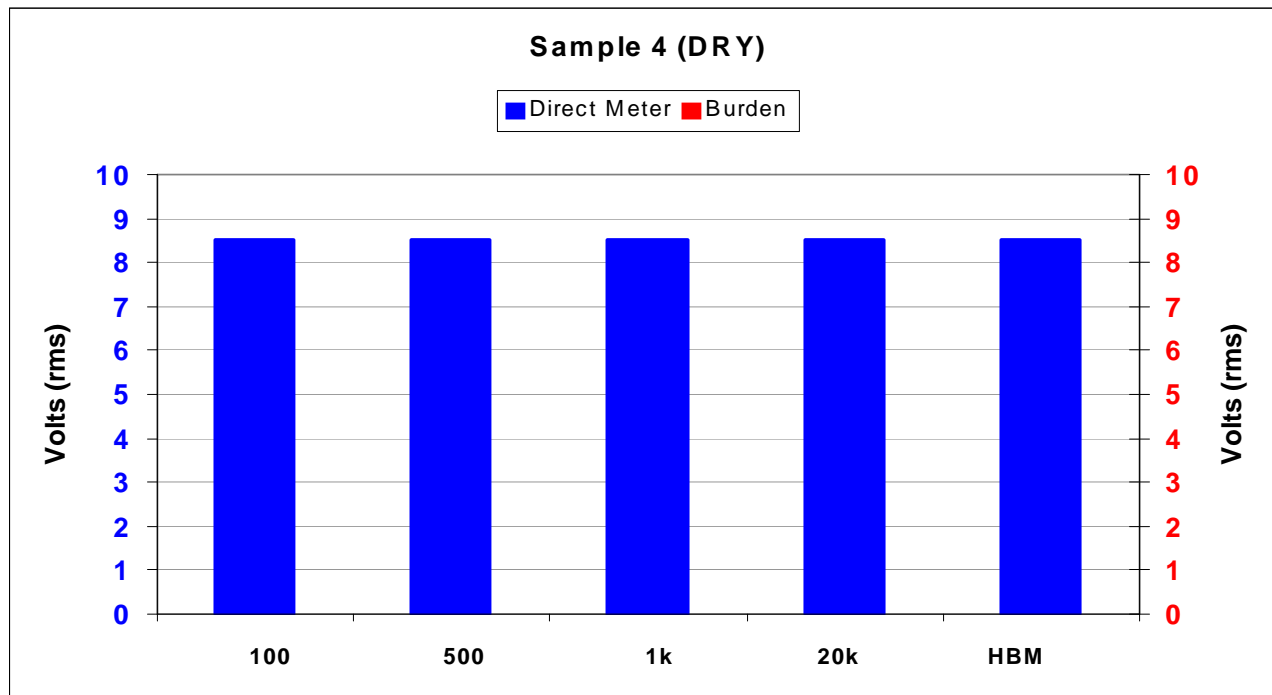
# Different Burden Resistance



**Sample 3 – (50% Sand 50% Salt)**

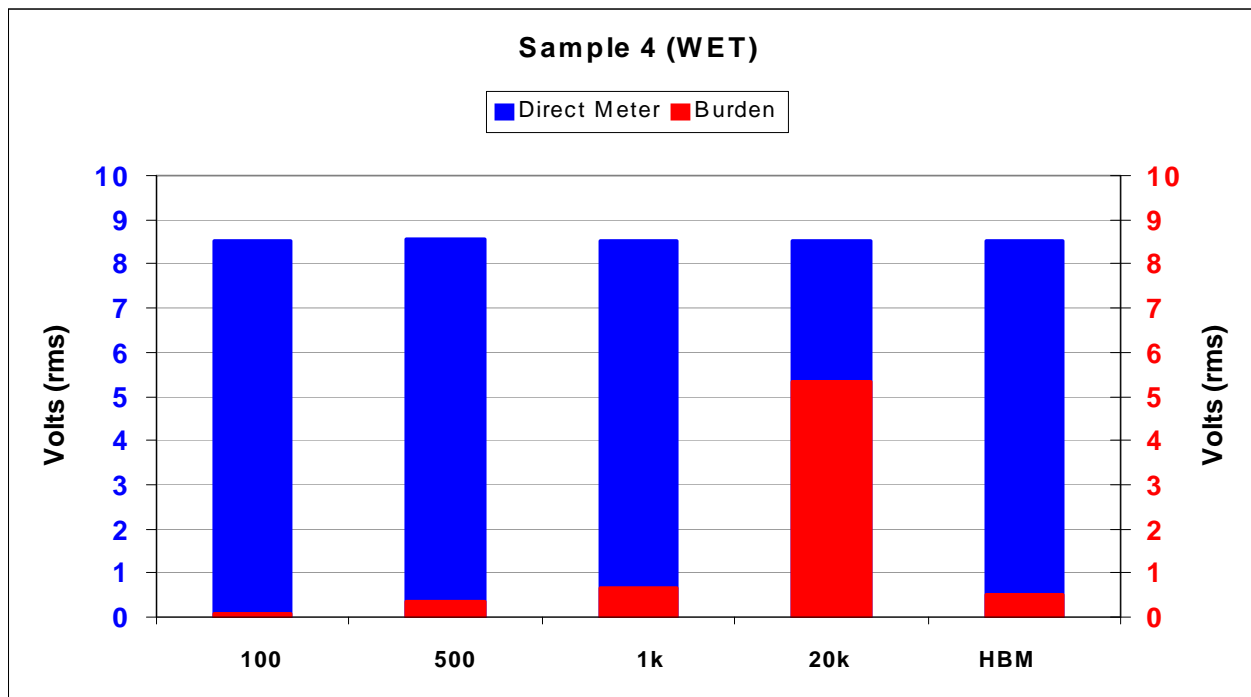


# Different Burden Resistance



**Sample 4 – (100% Sand)**

# Different Burden Resistance

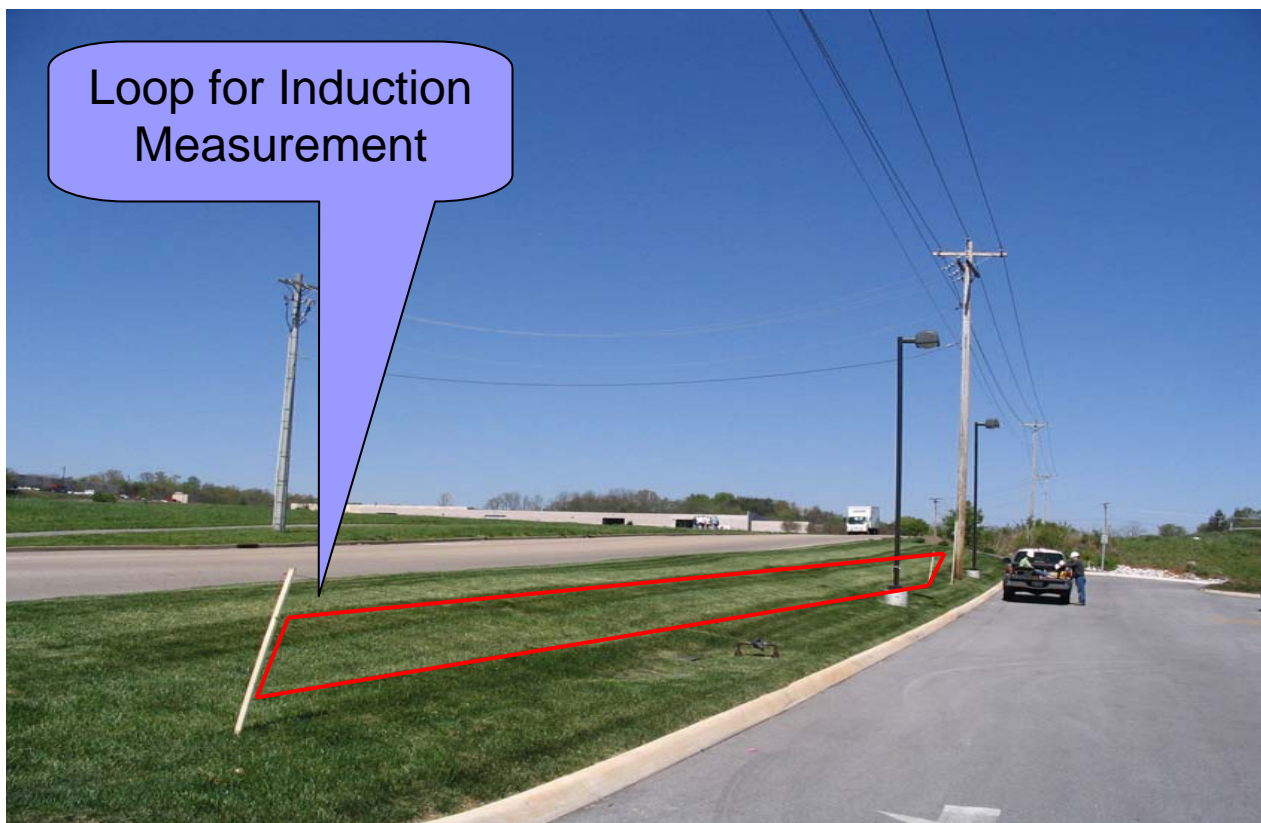


**Sample 4 – (100% Sand)**

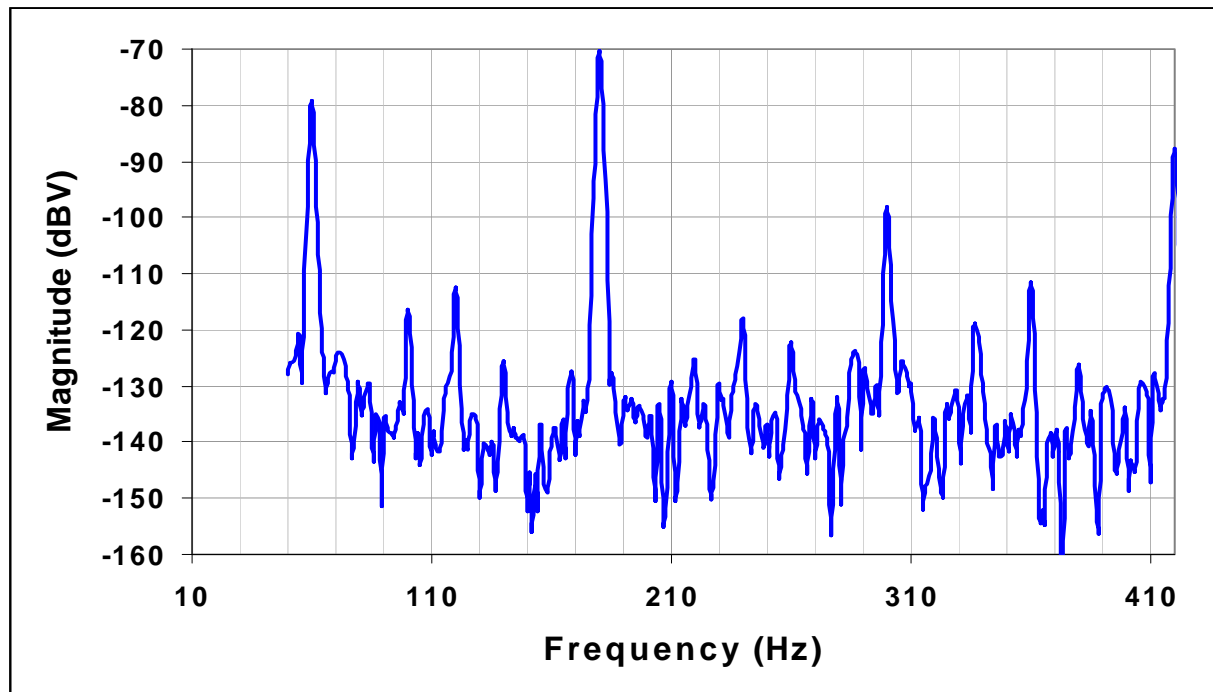
# Question 3

- Is there a way to distinguish an “induced voltage” condition from a direct fault condition?

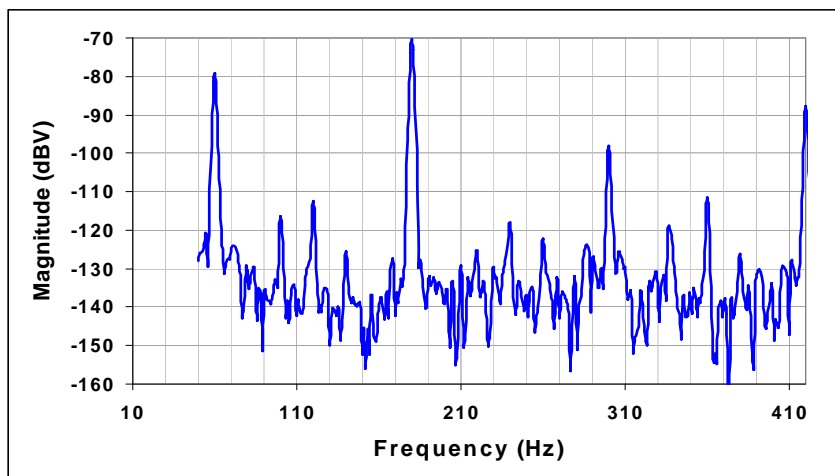
# Induced Measurement Field Experiment # 1



# 60Hz is present, but 180 Hz is Dominant Component from Distribution Line



# Induced Measurement Field Experiment # 2



**Similar Result as Before 180 Hz  
Dominates**



# Field Trial #1



First Pole Measured with a lot of Local Powered Equipment and Pad Mount Transformer



# Direct Contact



60 Hz



120 mV



# Field Trial # 2

Distribution Line Behind Trees



Second Pole Measured with Similar Electrical Gear in Area as Pole 1

# Voltage Measurement Induced



180 Hz



Human Model 22 mV

# Body Model verses Direct Meter Frequency Reading



Direct Meter Reading



Meter Reading with Human Model



# Field Trial # 3



Parking Lot Fence Under Distribution Line

# Voltage Measurement indicates Induced Source



321 mV



180 Hz

# Voltage Measurement Induced



238 mV



180 Hz

# Conclusions

- Human Model or 1 k ohm resistor may be suitable for quick check
- Measuring frequency removes ambiguity of human model, direct or induction
- Soil conditions effects human model, low voltage reading will become higher during wet conditions, 60 Hz frequency reading with a simple multimeter indicates a possible direct contact
- When predominant frequency of 180 Hz is measured on conductive objects that are not connected or grounded to the power system, the voltage is more than likely induced