



EPRI Safety Related Research Programs and Projects

Doug Dorr
Electric Power Research Institute
Manager – Advanced Monitoring Applications Group
PQSynergy 2012

EPRI Research Related to Contact Voltage

- EPRI has been conducting research on contact voltage concerns since the late 1990s
 - Provide unbiased information to the industry on the issue
 - Conduct core research as identified by the electric utility industry
 - Evaluate advanced diagnostic equipment to improve worker and public safety relative to the subject matter
 - Maintain an informational website and support industry forums (like IEEE P1695 & the Jodie Lane annual conference)

Elevated Neutral-to-Earth and Contact Voltages in Distribution Systems

2009 Research Update and Guidebook Materials

1017843

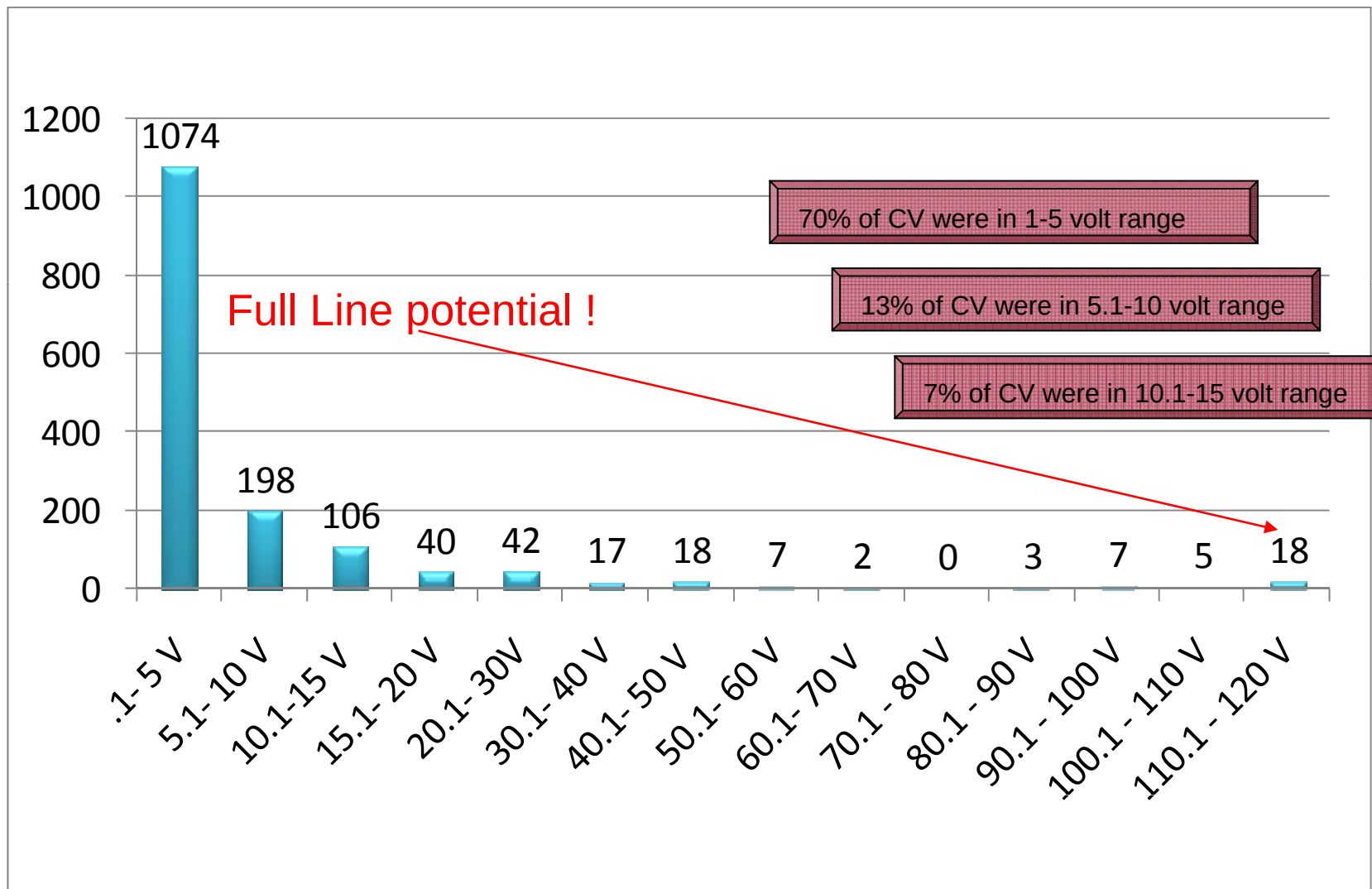
Final Report, November 2009

EPRI Project Manager
D. Dorr

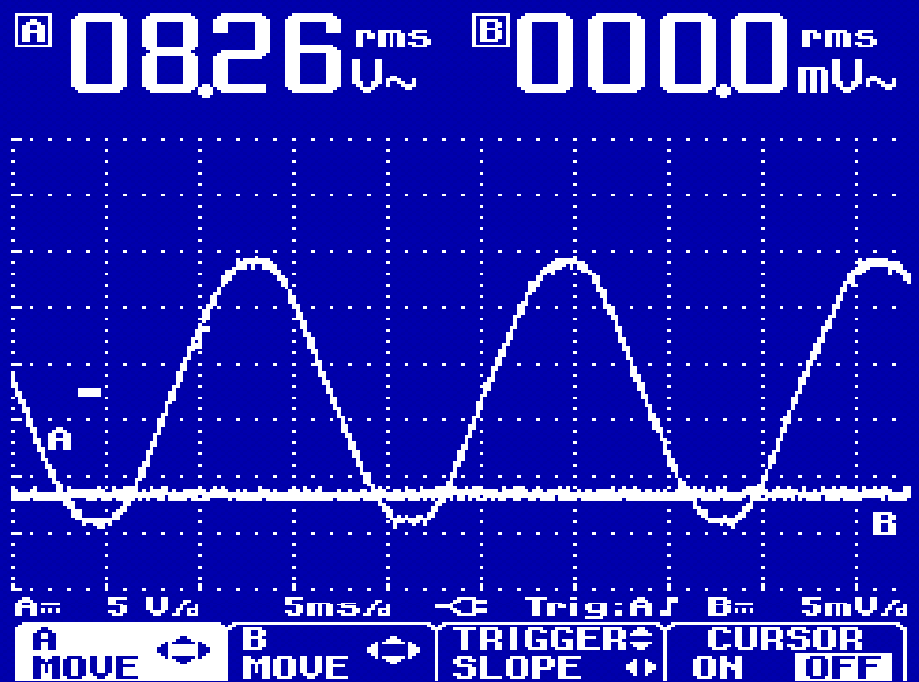


Contact Voltage Histogram

(Source Toronto Hydro 2009 Jodie Lane Conf)



Excavated handwell with live conductors had been paved over



Degraded split-bolt tape insulation



PVC tape on split-bolt splice improperly applied



Photos from 2009 Jodie Lane Conf. Toronto Hydro Presentation

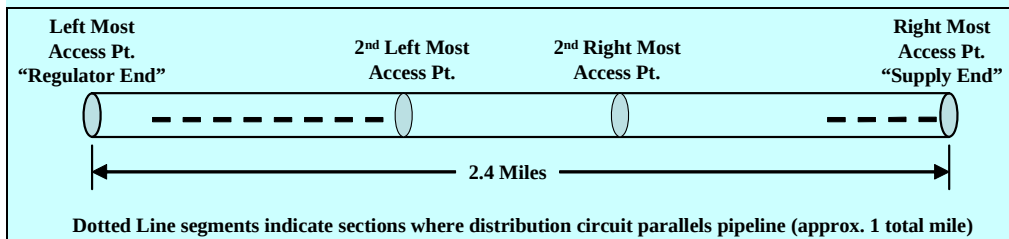
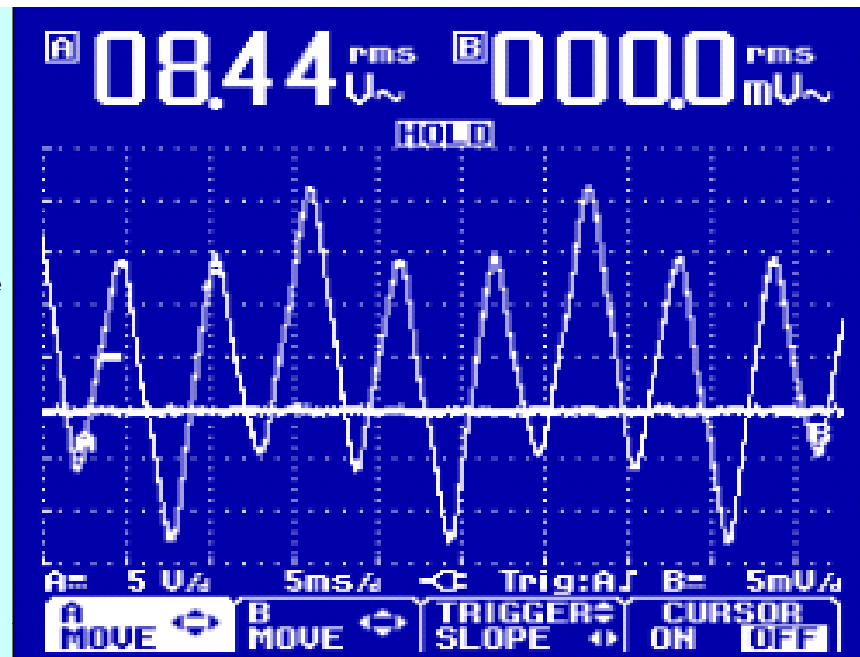
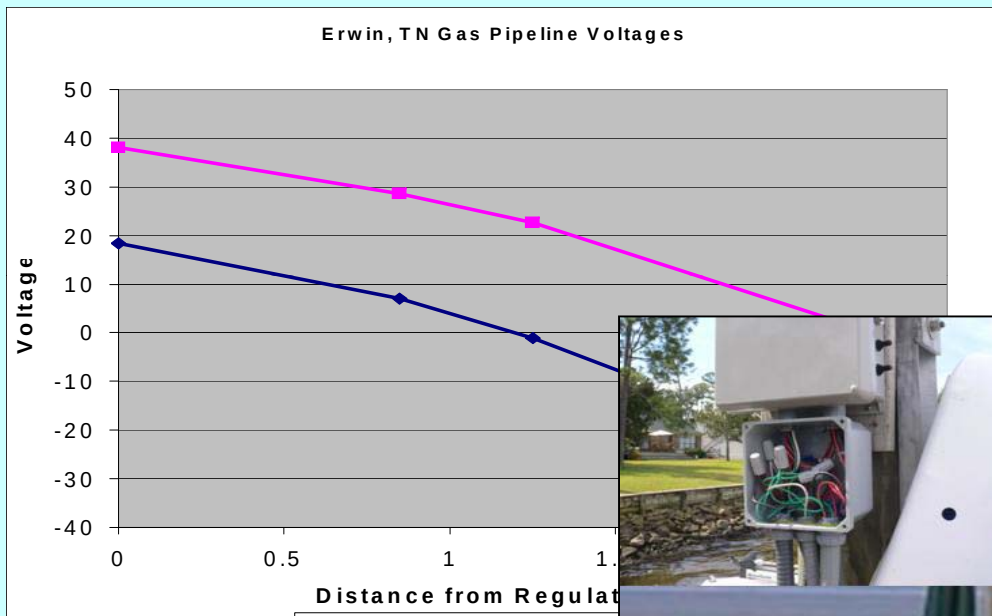
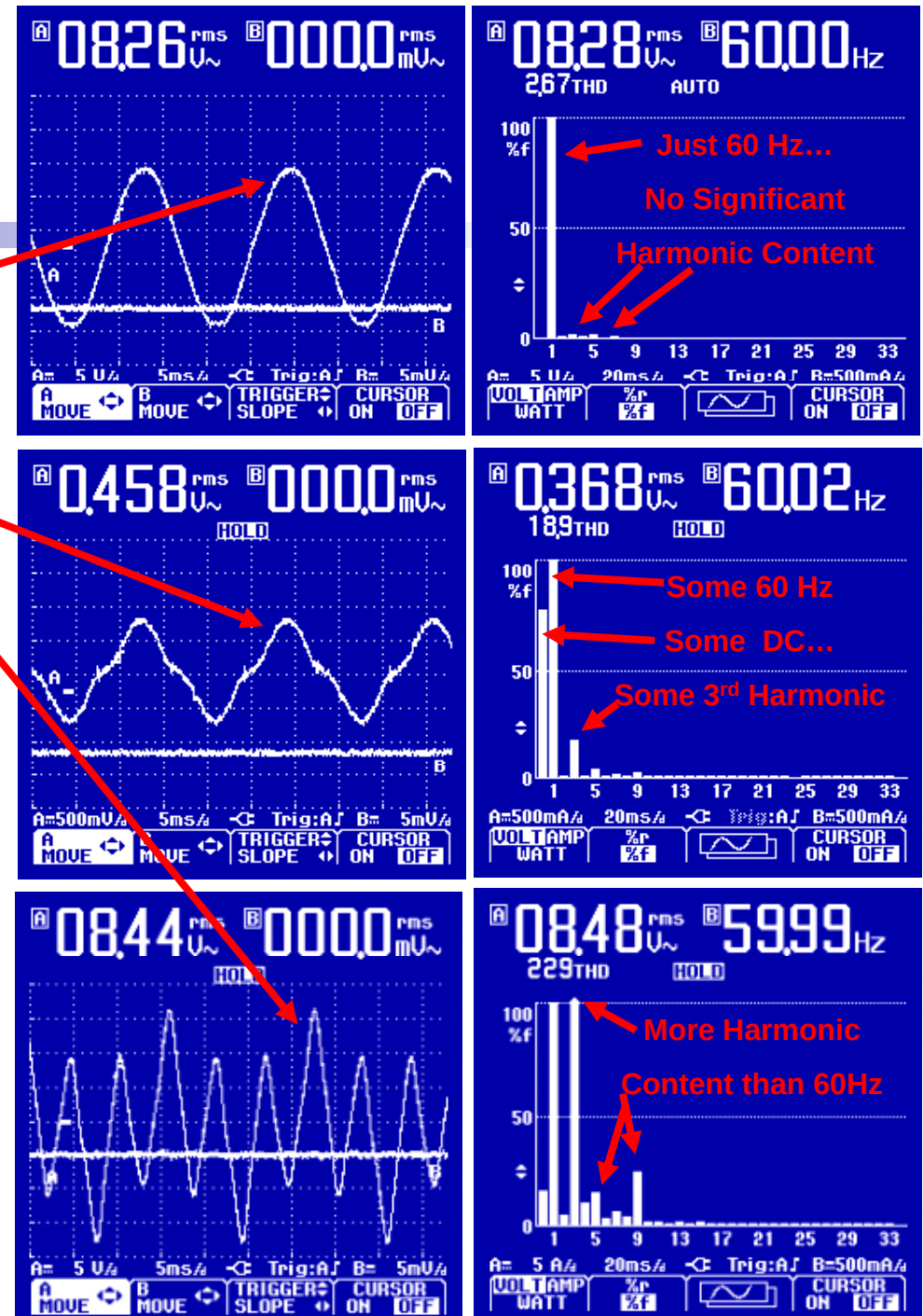


Figure 1-A Visual of the segment of pipeline indicating the 4 (four) voltage access points and the parallel distribution line locations.



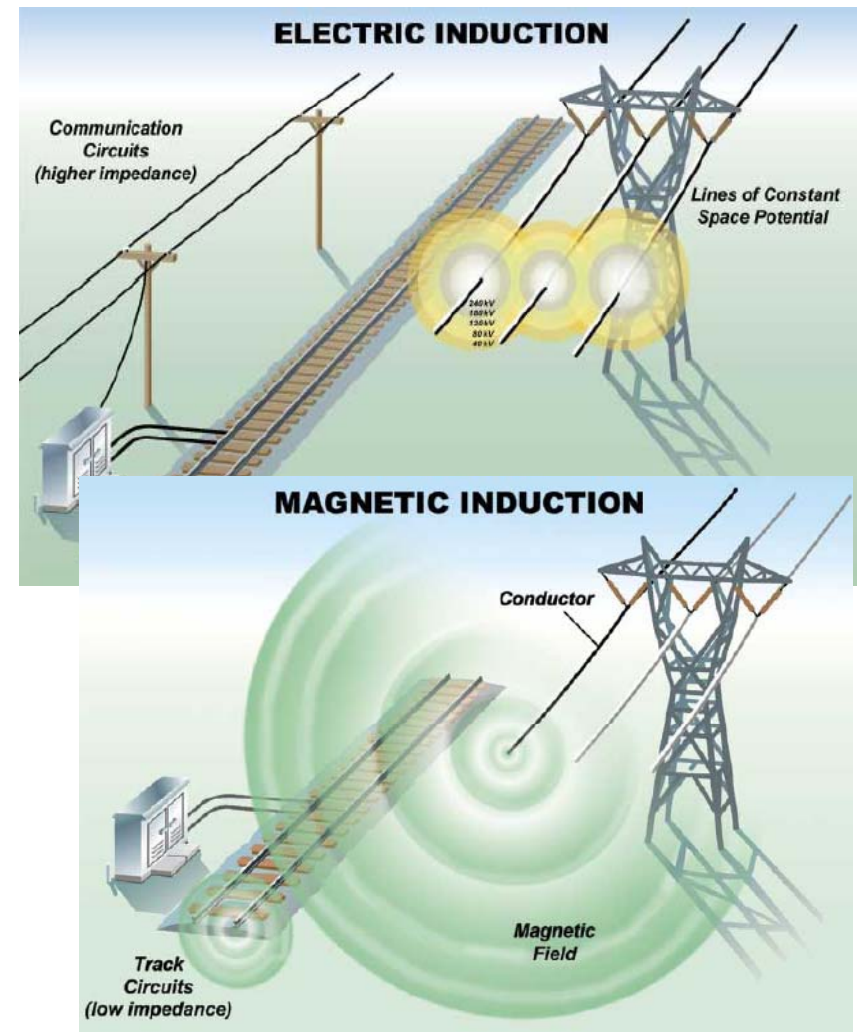
EPRI Finding: Waveform Analysis Allows for ID of Contact Voltage Sources

- 60 Hz Faulted Phase Conductor
- Neutral to Earth Voltage
- Voltage on Gas Pipe Line



Technical Background for Energized Objects

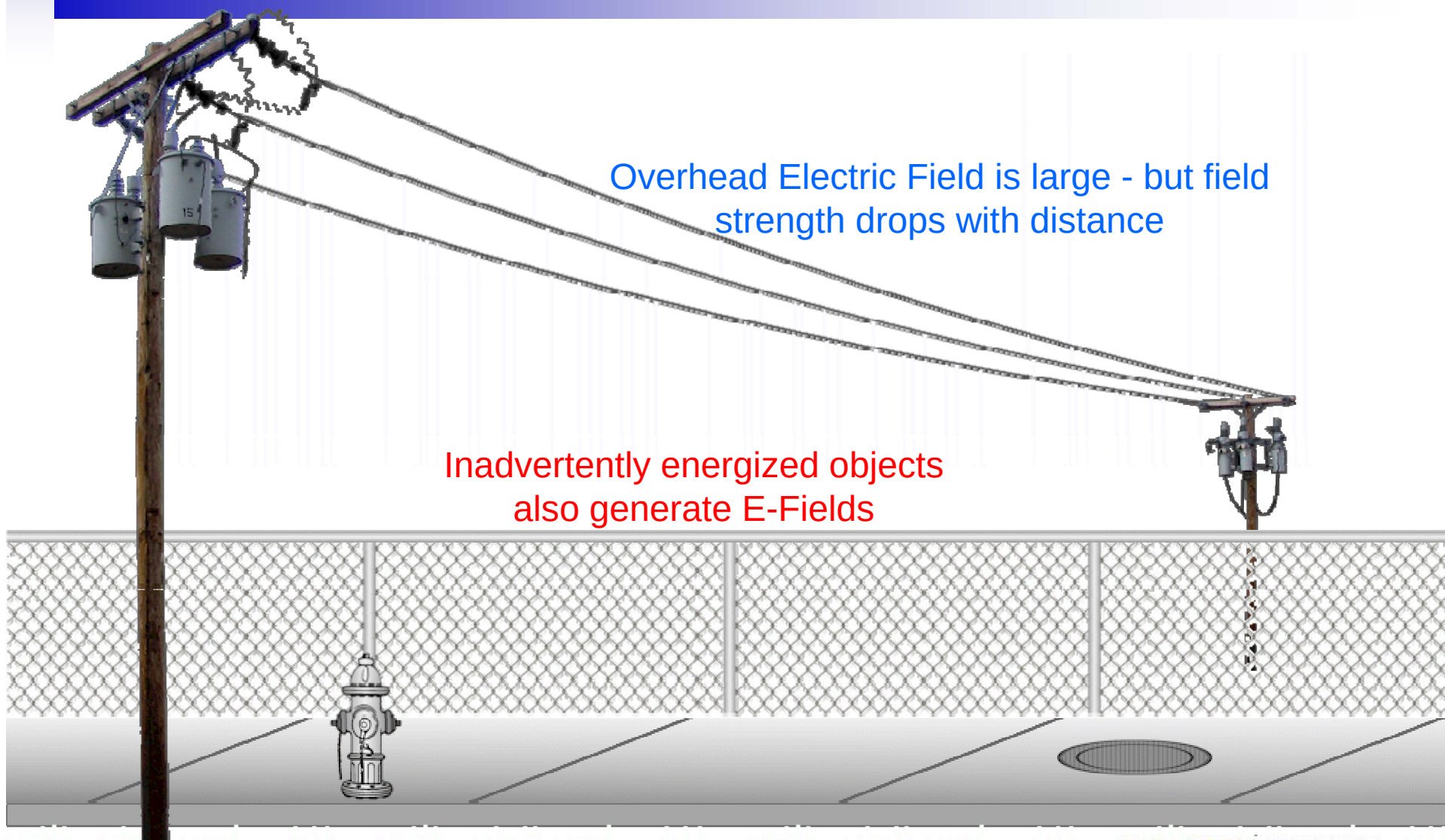
1. Power lines and other objects that are energized (intentionally or unintentionally) generate an **“Electric Field”** or **“E Field”** that varies with the voltage level
2. If current is also flowing the power line or object can also generate a **“Magnetic Field”** that varies with the amount of current flow
3. Power lines typically emit both electric and magnetic fields (voltage is present and currents are flowing)
4. Inadvertently energized objects and surfaces **always** emit an Electric Field
5. By looking for Electric Fields in underground areas, we can locate objects that are energized (but shouldn't be)



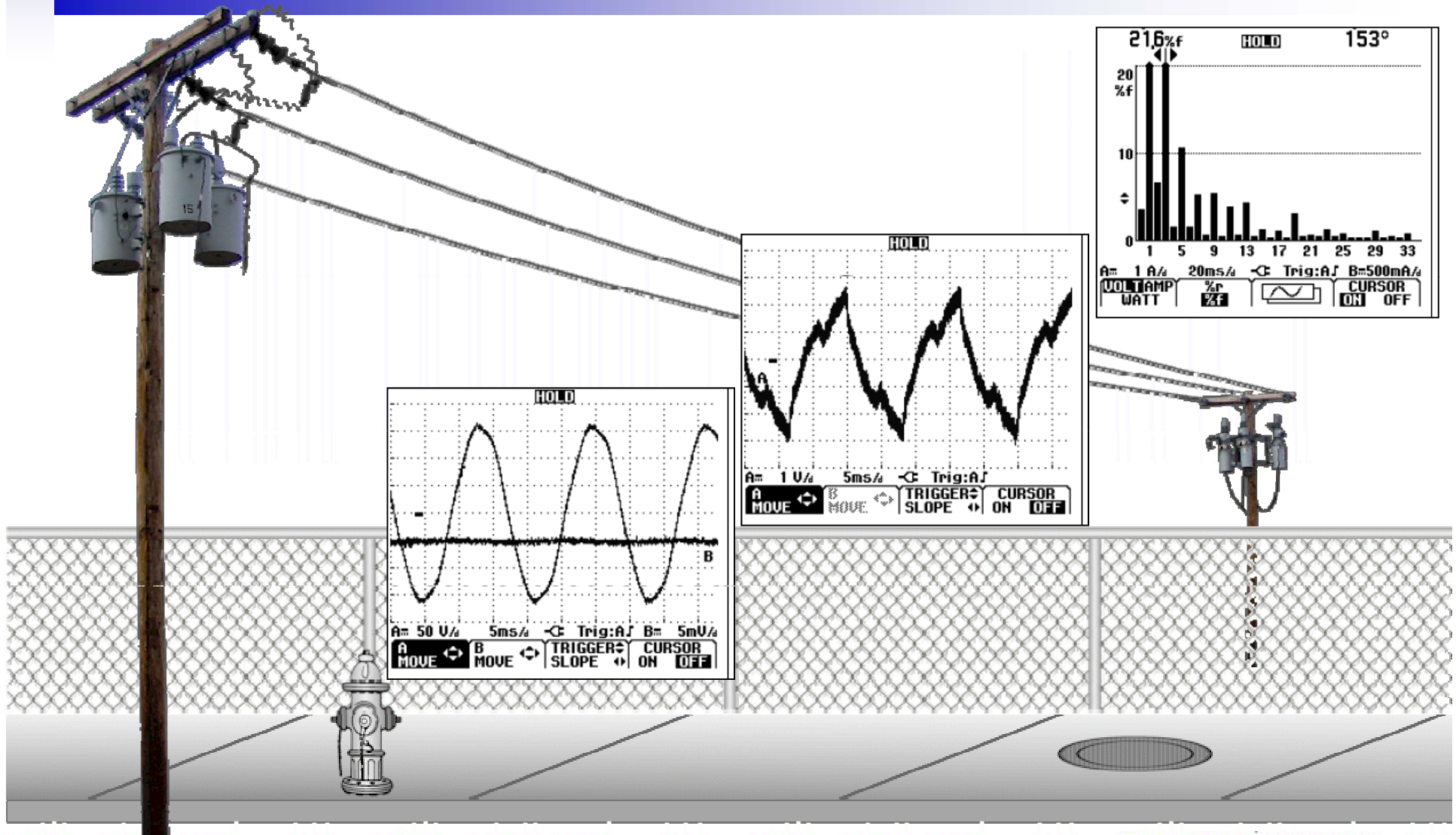
Power lines and all other objects that are energized generate an “*Electric Field*”

Overhead Electric Field is large - but field strength drops with distance

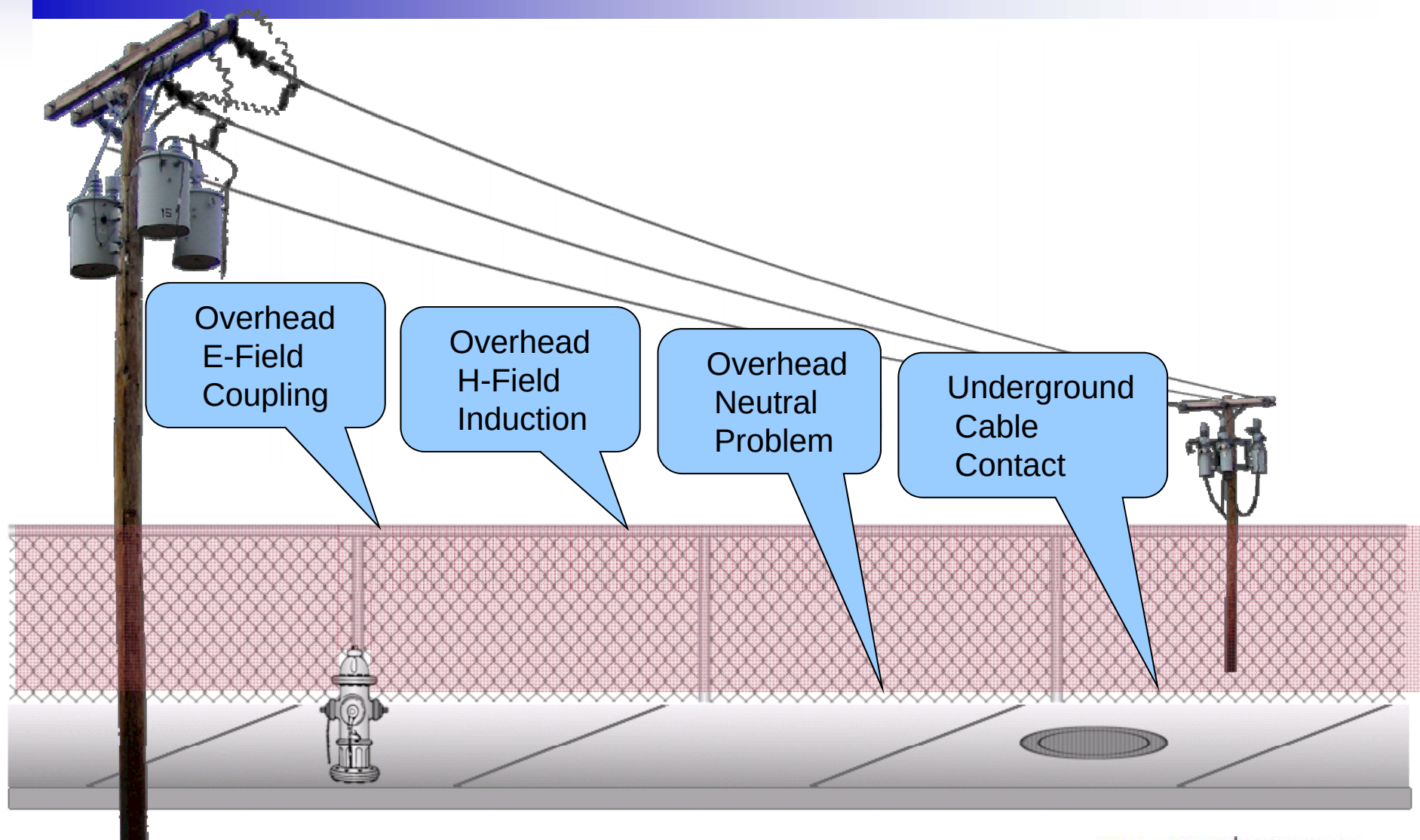
Inadvertently energized objects also generate E-Fields



By looking at the harmonics generated by the Electric Field we can learn more about the cause

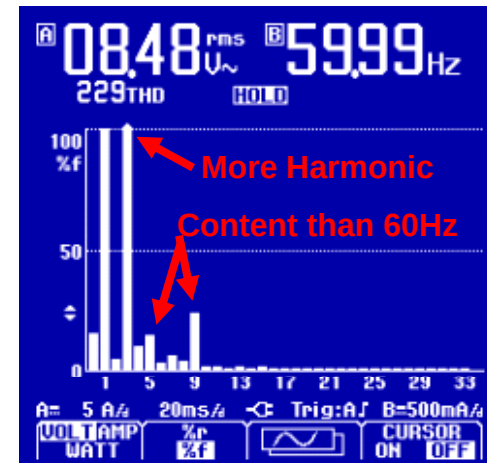
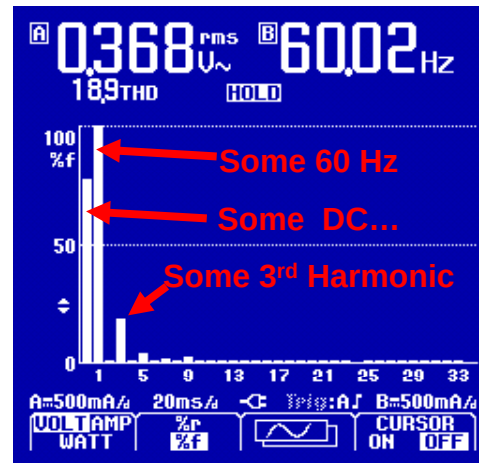
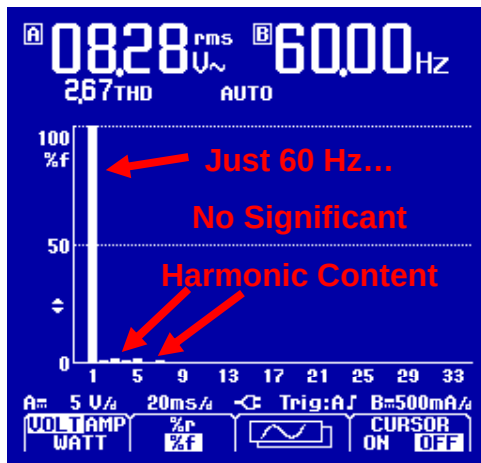


Example: The fence can be energized at least 4 ways! Harmonic analysis and trending provides insight



Technical Background for Harmonic Analysis

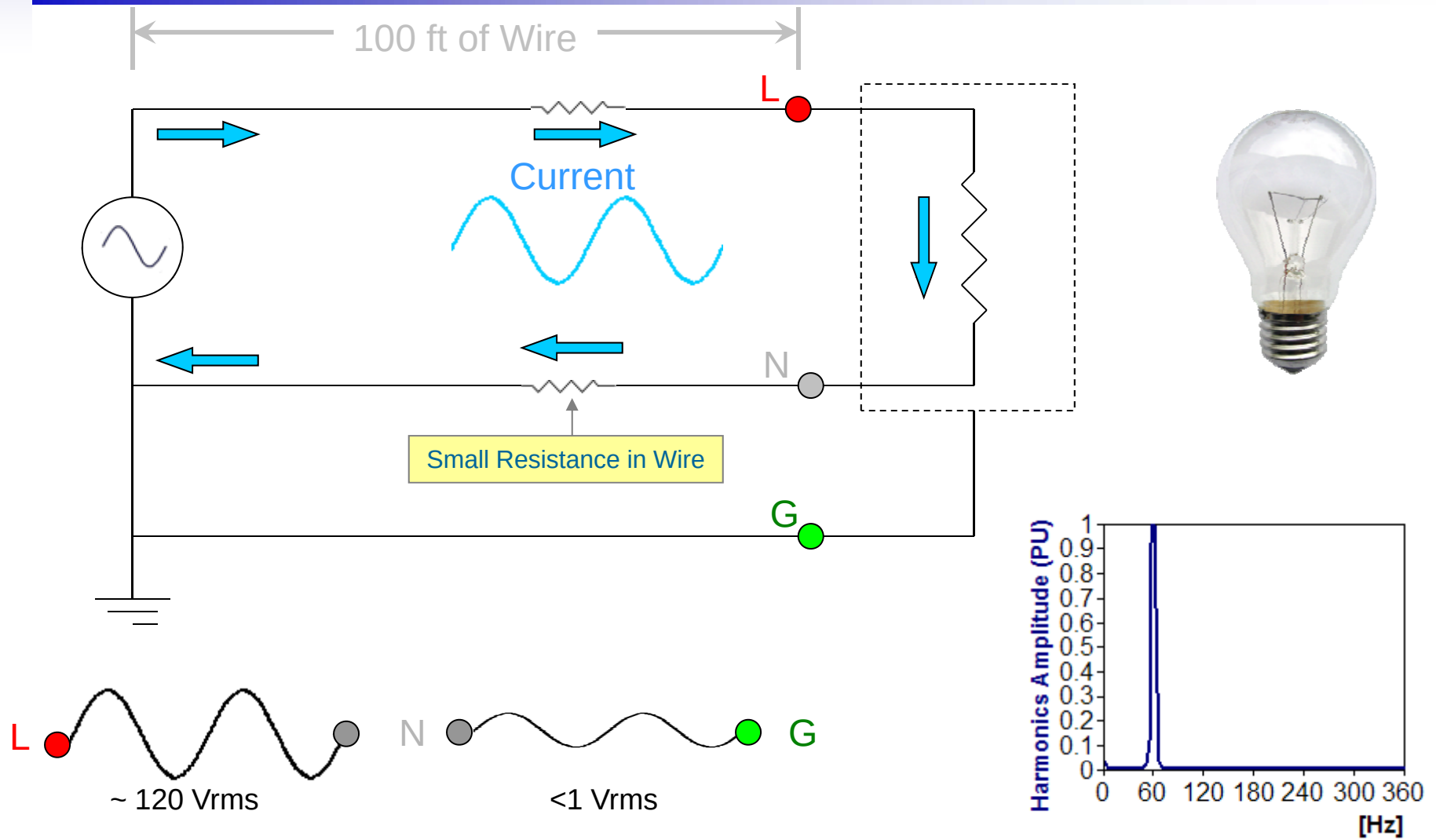
1. Every periodic waveform or signal can be broken up into a series of harmonics (or multiples of the fundamental frequency)
2. Once the waveform is broken up into it's harmonic frequencies (or bins as they are called) we can use this information to decide what to look for... (cable fault, neutral problem etc.)



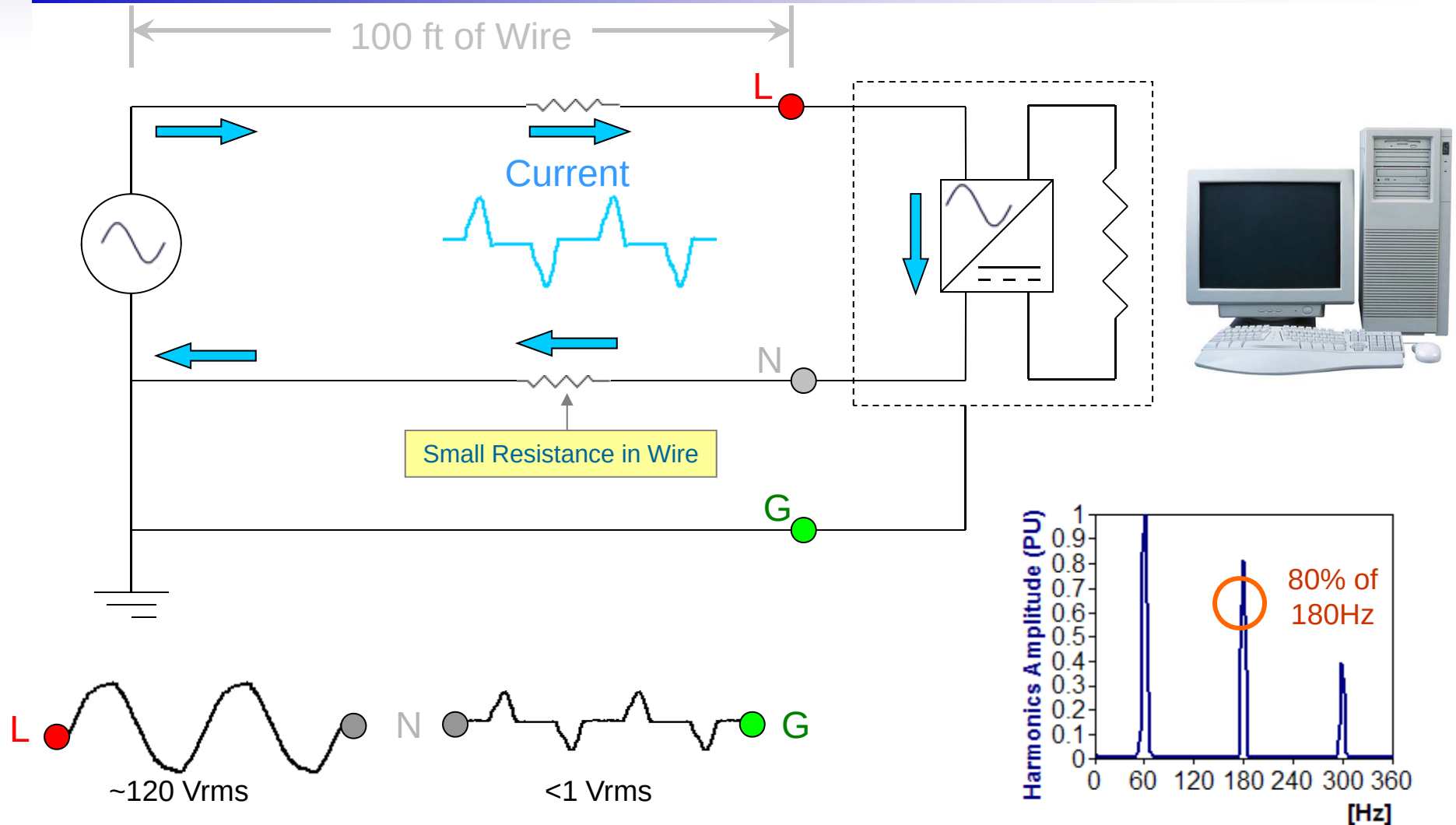
Why are Harmonics Important?

- The majority of power electronic loads draw non-linear current – meaning the voltage and the current have different waveshapes
- These loads include computers, LCD and plasma TVs, Copiers, Fax Machines, Electronic Ballasts for Lights etc.
- When looking at neutral voltage drop (from the neutral impedance only) there is a telling difference in what you will measure
- **Let's look at two examples using a linear load (light bulb) and an non-linear load (desktop computer)**

Neutral Voltage (Light Bulb Load)



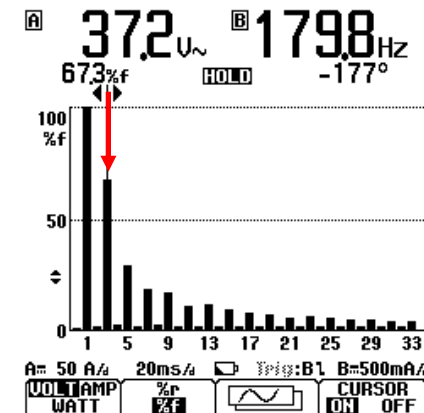
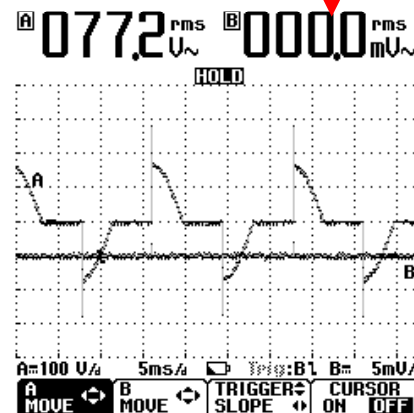
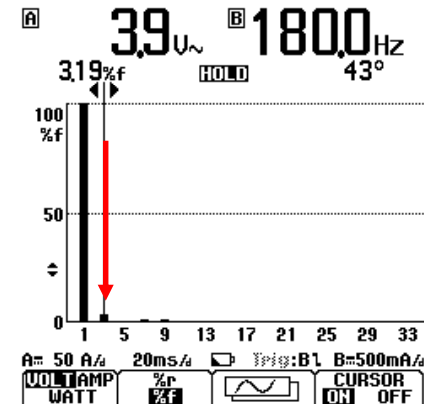
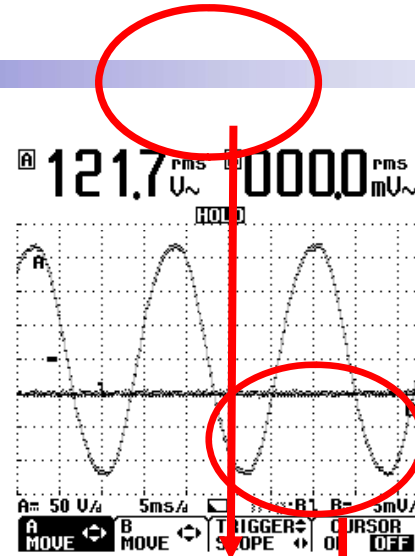
Neutral Voltage (Computer Load)



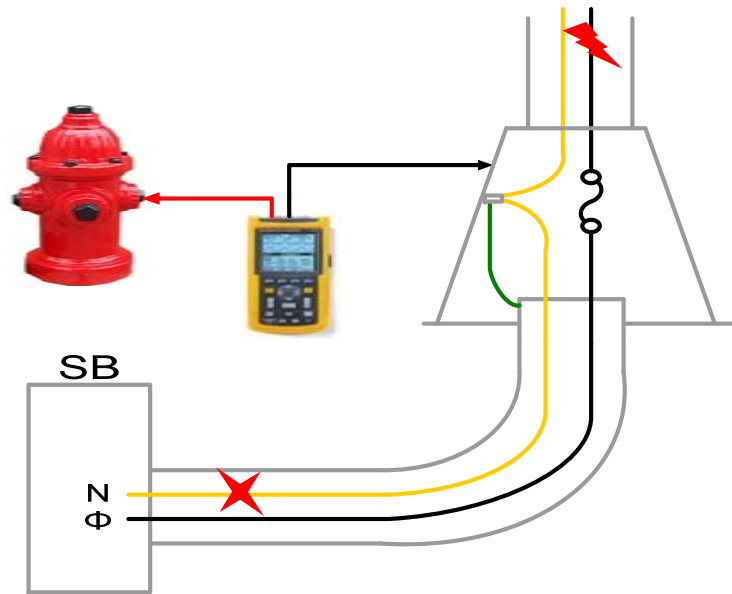
Harmonics Analysis

< 10%: Phase
Clean 60 Hz Sine wave
Low 3rd Harmonic Content

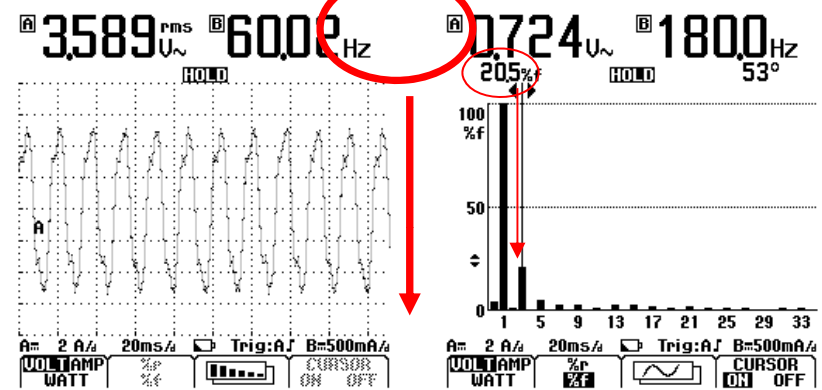
>10%: Neutral
Distorted 60 Hz Sine wave
High 3rd Harmonic Content



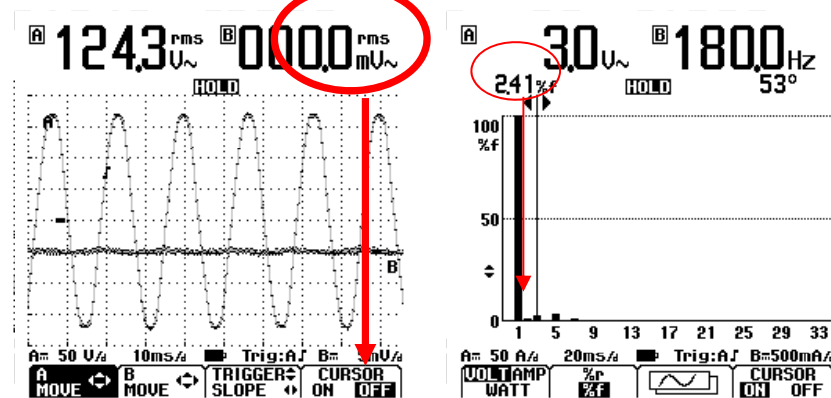
Street Light Field Studies



Street Light on Vernon Blvd



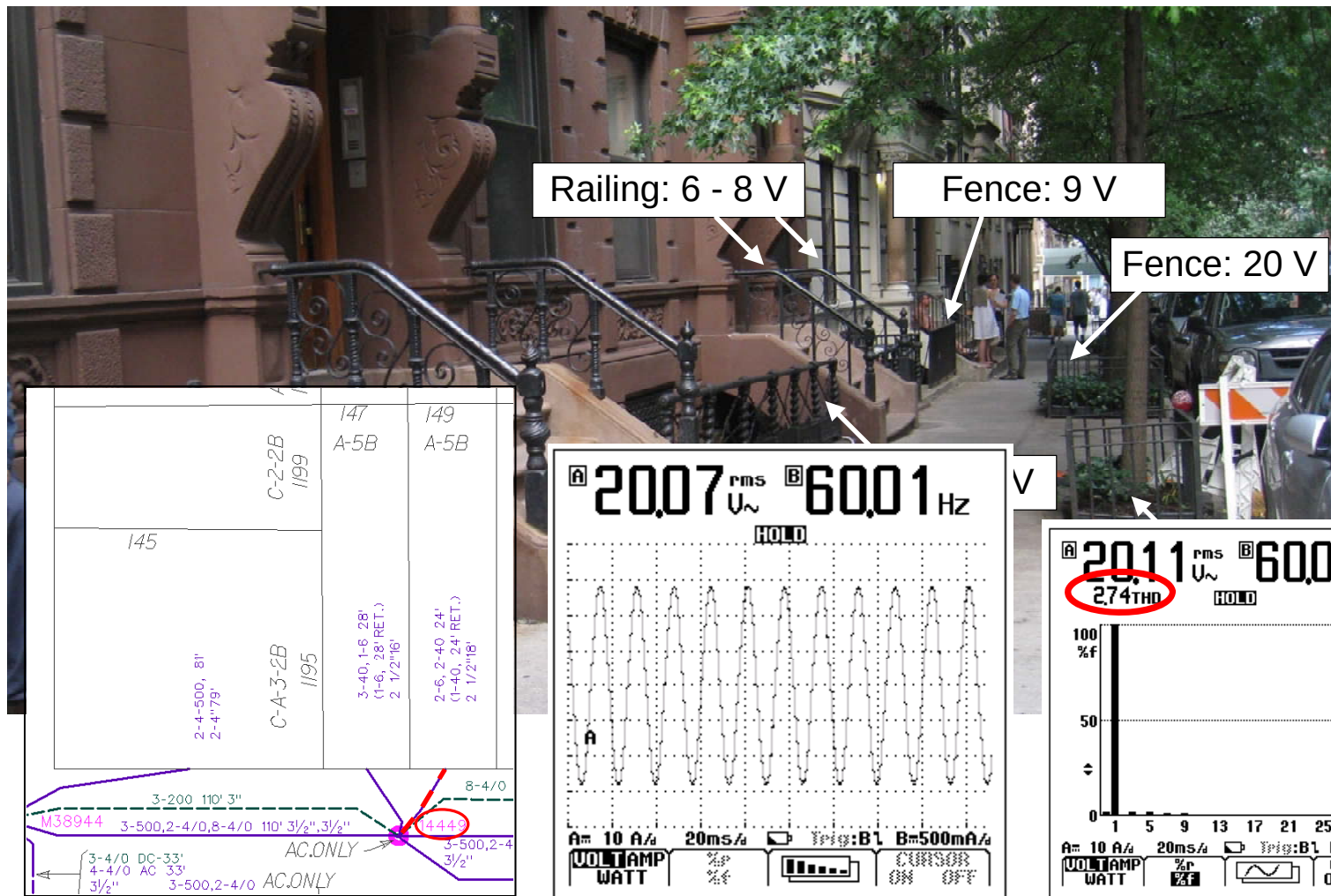
Walk Sign on Rogers Ave



Case Study 1: Cable TV wires



Case Study 2: Multiple Energized Objects



Where We are Today

ECREMK		EMERGENCY CONTROL SYSTEM		REMARKS	
DIV 01	WORKID 310531	JOB NUMBER ME1000409			
ACT ADDR	70 78	ST	MUNI		
REMARKS/RESTRICTIONS:		ACTIONS(DISPLAY OR ADD)		MULTI REF SCRIN (Y)	
LINE NO					
001	BTX149 POWER SURVEY CORP SARNOFF PROGRAM.M/H COVER M&S 37J				
002	VOLTS 20.7 GRND WATER SPIGUET. N/P 9-10:30AM TUWS & FRI. TR				
003	K-21 3HRMNIC-1.2				



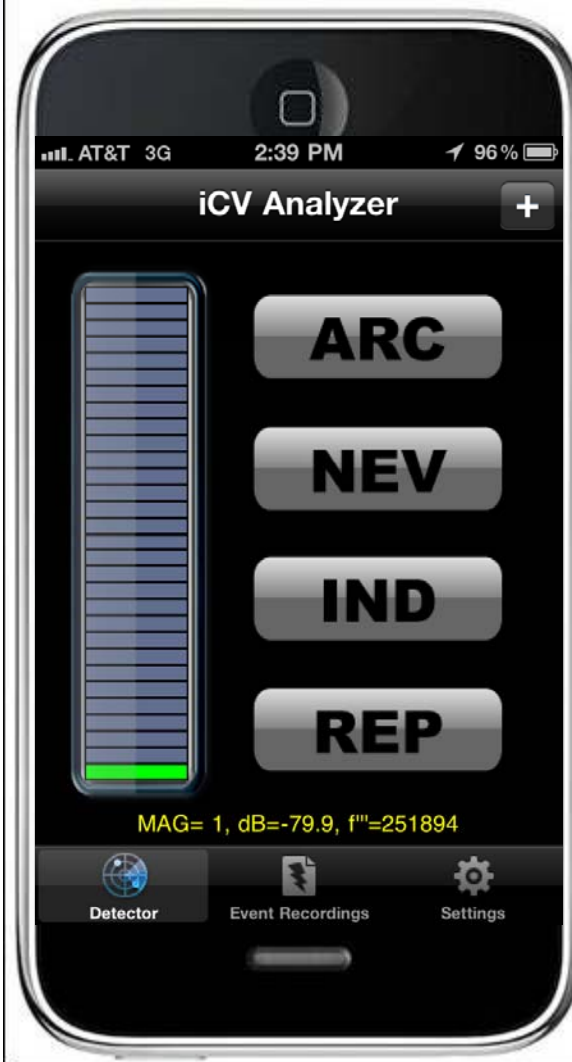
- ☐ 3rd Harmonic content displayed on B-ticket
- ☐ Simplify Analyzers
- ☐ Expand training
- ☐ Work prioritization

The Hardware – Provides Several Technology Breakthroughs...

- **Identifies the Source of E Field**
 - Faulted Phase Conductor
 - Neutral to Earth Voltage
 - Induced Voltage
 - Arc' detection before a surface becomes a shock hazard
- **Directional LEDs for Fast ID**
- **Digital Signal Processor**
 - Minimizes false positive IDs
 - Less User Complexity
 - Improved directional sensitivity



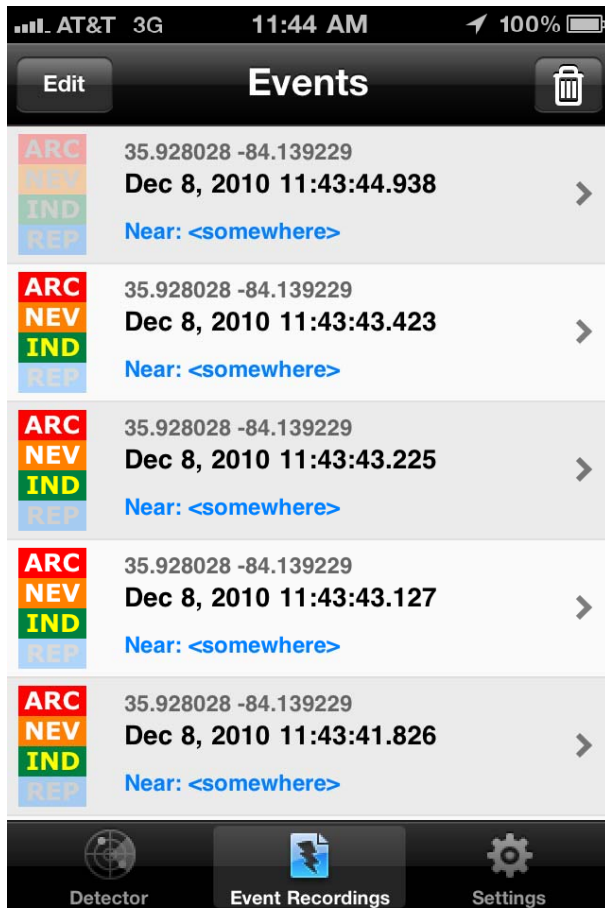
iCVAnalyzer Main Screen - App Highlights



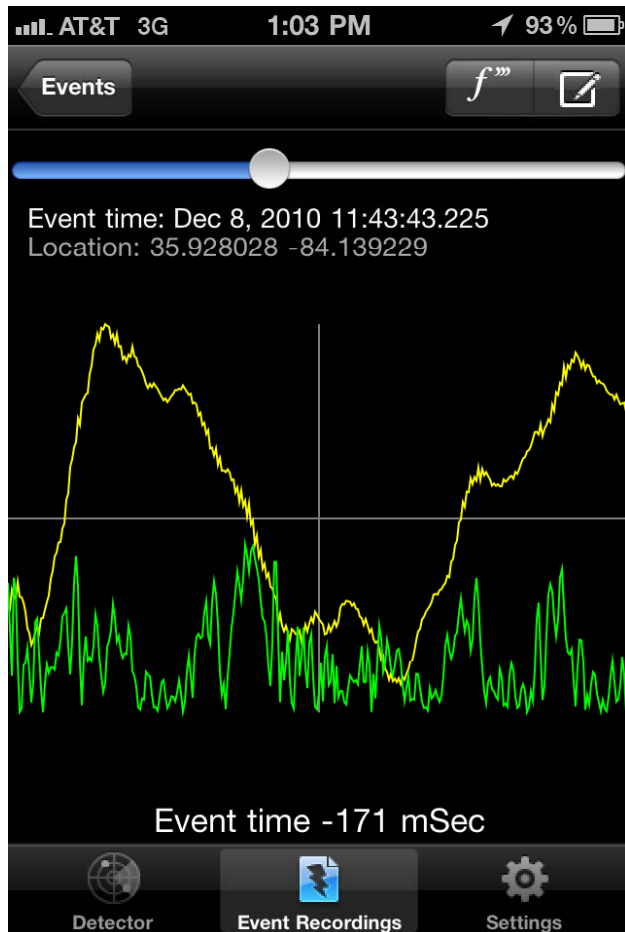
- Function bar displays across bottom of screen:
 - Detector (this screen)
 - Event Recording
 - Settings

iCVAnalyzer Event Screen

- Events screen
 - Touch Right arrow to select event waveform to display

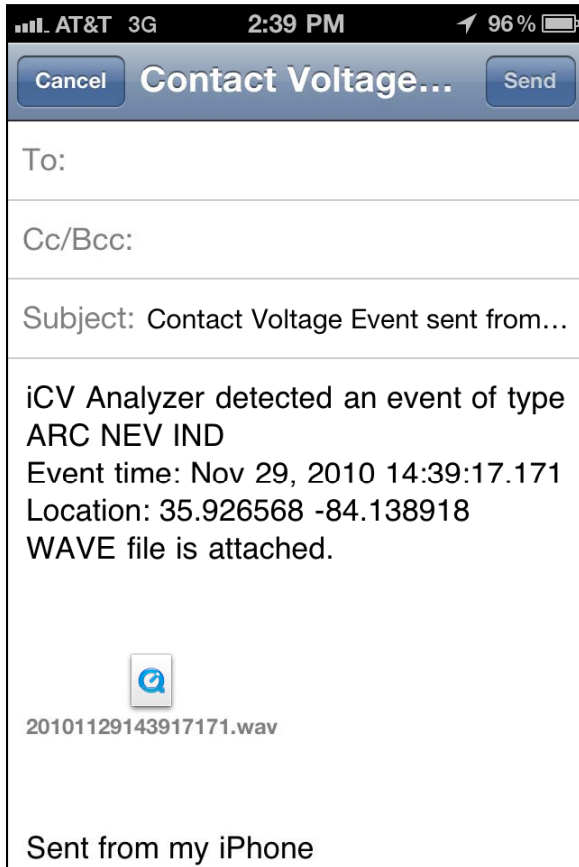


iCVAnalyzer Waveform Screen



- Waveform Screen with 3rd Derivative
- Yellow trace – event wave form
- Green trace – 3Rd derivative
- 2 seconds of data total. One second before event, one second after event

iCVAnalyzer Waveform Screen



Email .wav file

Fill in addressee and touch **Send** button to send waveform .wav file

Leadership Idea - Diagnostics Robot for Distribution UG Structures Applications

- Project Objectives

- Leverage existing robotics technologies to customize a system for; structure inspections, and elevated risk work
- Use visual recognition and/or “transmit the visual to the remote expert” to take human subjectivity out of the decision making process
- Create prototypes from proven robotics platforms and identify a solid commercialization partner

- Value

- Worker Safety
 - Smoking manhole first response
 - Perform high safety risk work
- Visual Remote Control
 - Monitoring and data logging
- Hazard Diagnostics
 - Conduct pre-entry evaluation
 - Detection options; arcing, gases, acoustic, infrared, optical

