Using Harmonic Analysis to Classify Encountered Errant Voltages

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Central Hudson
Gas & Electric Corporation

- Located in the Mid-Hudson Valley of New York
- 300,000 customers in 2,600 square mile area
- 7,300 overhead pole miles and 1,340 trench miles
- Approximately 230,000 facilities tested annually 2006 through 2012.

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NYS PSC Order 04-M-0159

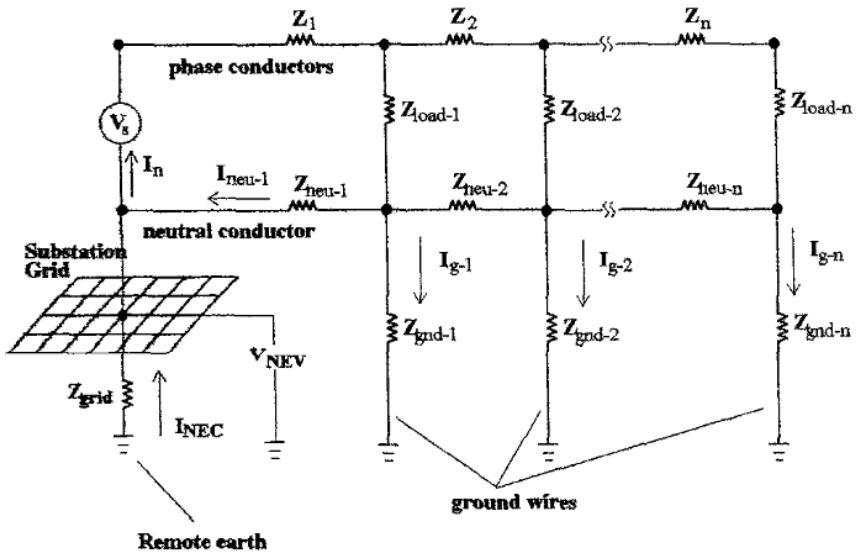
- All company-owned overhead distribution, transmission, URD, manhole/pullboxes, substation fences, and municipal owned street lights and traffic signals must be tested.
- Per the PSC Order, a stray voltage is defined as a non-naturally occurring voltage (contact voltage)
- 2008 Order Revision states that utilities must mitigate any stray voltage equal to or above 1 V_{ac} compared with old standard of 4.5 V_{ac}.
- Since 2009, Central Hudson has been applying harmonic and power quality theory to classify voltages found during stray voltage testing.

Types of Voltage Found in Field

- Contact Voltages
  - Faulted electrical equipment – motors, heaters, etc. where breaker has not operated
  - Inadvertent energization of conductive object – service boxes, manholes, streetlights, etc.
- Naturally occurring
  - Neutral to Earth Voltage – Current flow through neutral resistance
  - Electric Field Coupling – Electric field from overhead line coupling voltage to conductive object in vicinity of electric field.
  - Harmonic Resonance – Power system currents interacting with circuit elements
  - Magnetic Induction – Current on a wire inducing voltage on a parallel pipeline, fence, or wire.

Multi Grounded Wye Distribution

$$V_{NEV} = I_{NEC} \times Z_{grid}$$



- Primary return path back to the source is generally the system neutral. The system neutral has a voltage associated with it due to the impedance in the wire. The return current that is flowing to earth can typically be 60% of the total return current.
  - The impedance to earth can become very small as the number of grounds increase.
  - By design a flow on the down ground can be expected.
- The neutral and the earth are bonded via a ground and should be at the same voltage potential however a resistance does exist between these two points thus causing a measurable potential or V(NEV)
- The potential between the system neutral and remote earth is known as neutral to earth voltage or (NEV).

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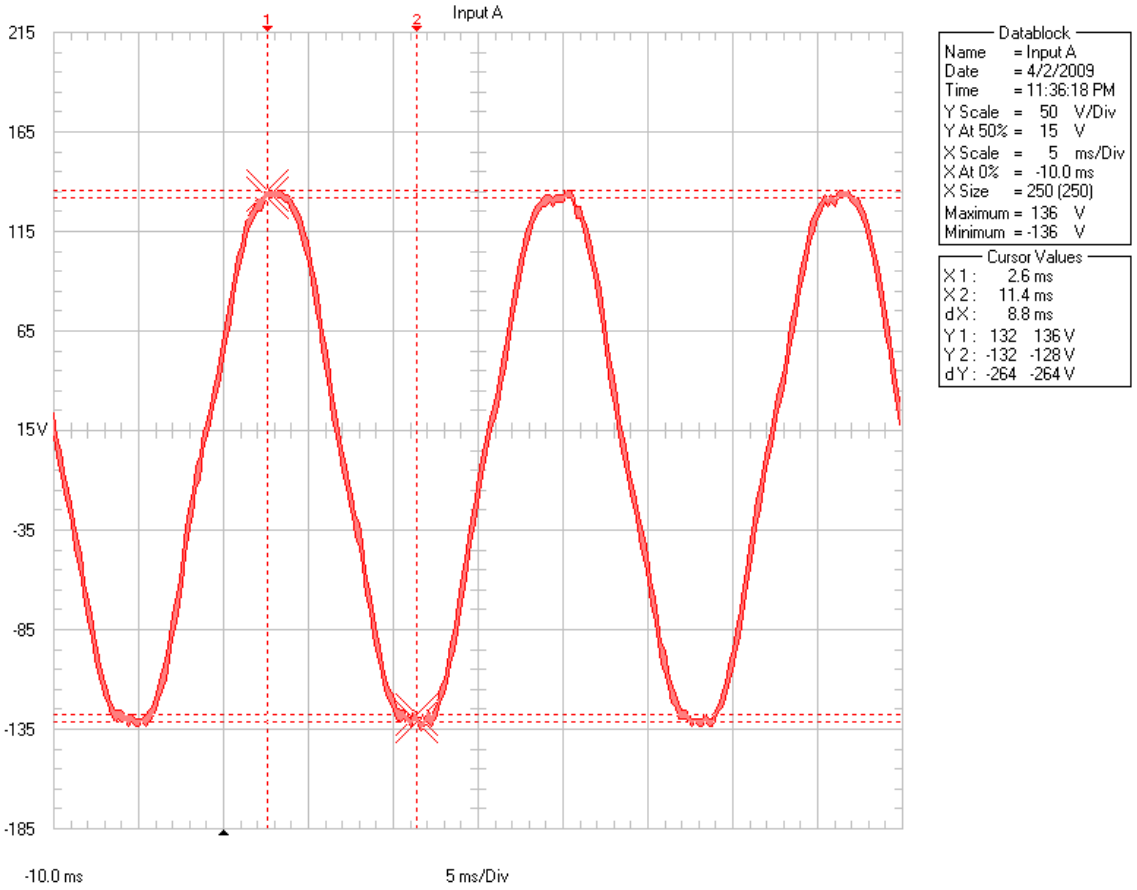
Examples of Voltage Sources

Contact Voltage - Oscillography



- Smooth peaks and valleys
- Clear 60 Hz sine wave
- No distortion present in reading

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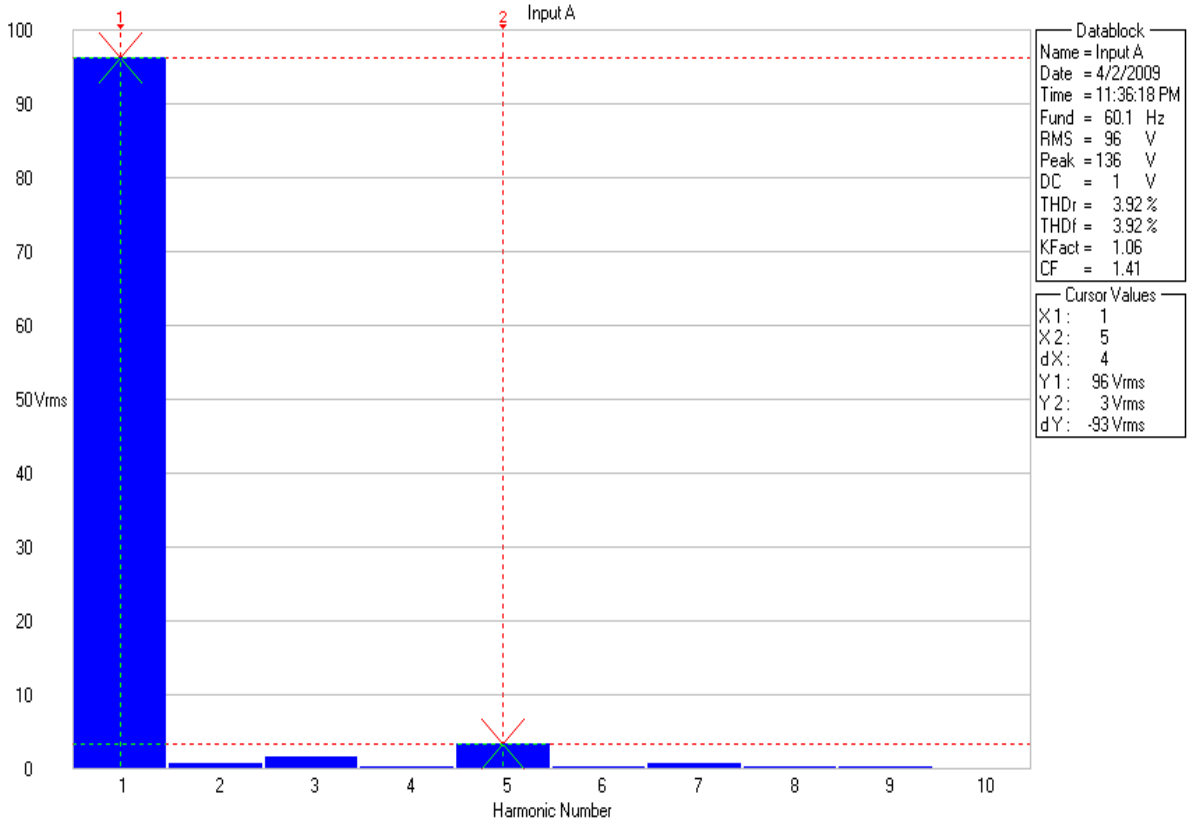
Examples of Voltage Sources

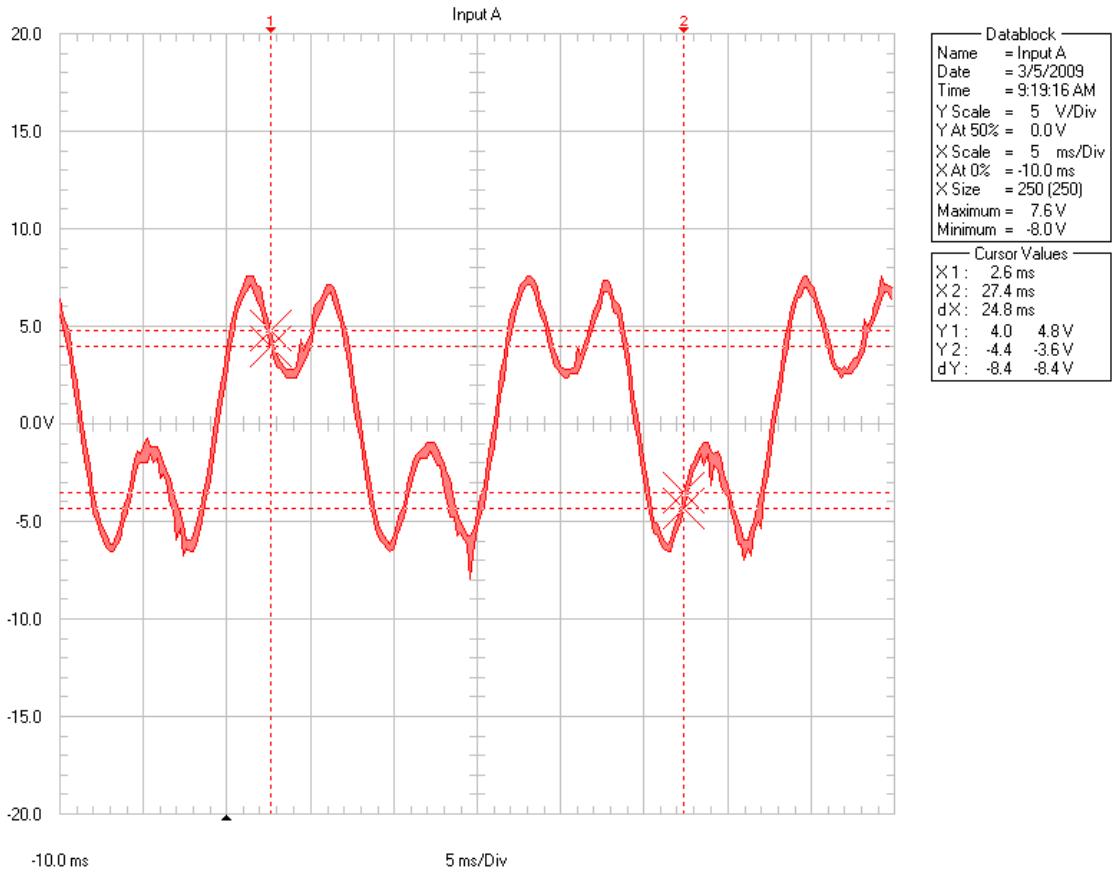
Contact Voltage – Harmonic Spectrum



- Less than 5% THD
- Almost all of the harmonic components in the 1st harmonic (60 Hz)

Examples of Voltage Sources

Induced Voltage - Oscillography



- No clear peaks and valleys
- Frequency of waveform not clear
- Distortion present in reading

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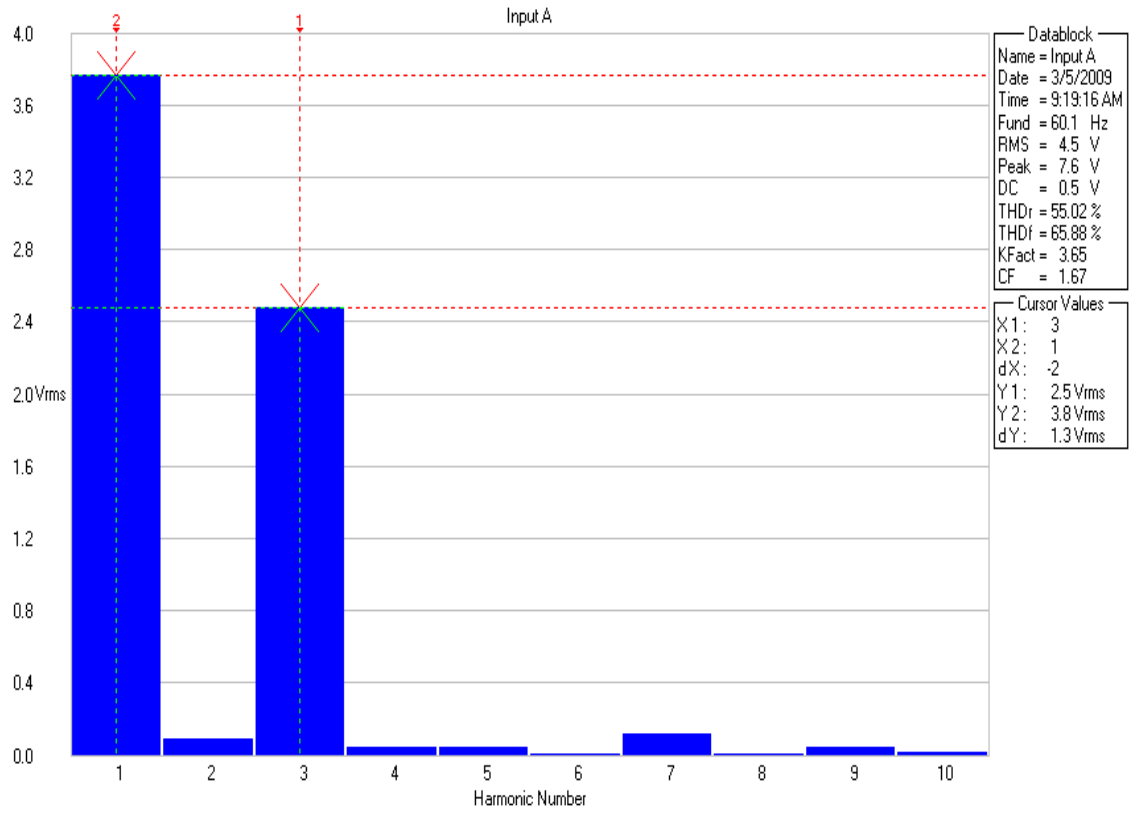
Examples of Voltage Sources

Induced Voltage – Harmonic Spectrum



- More than 10% THD
- High harmonic components outside of 1st harmonic.

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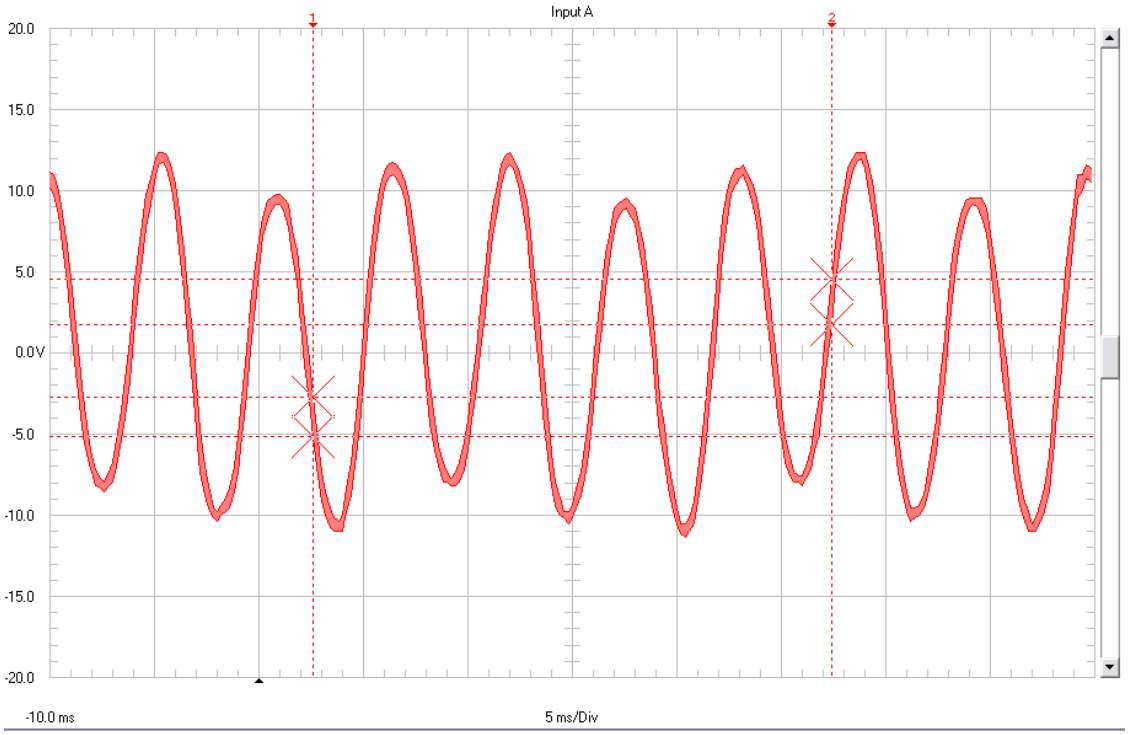
Examples of Voltage Sources

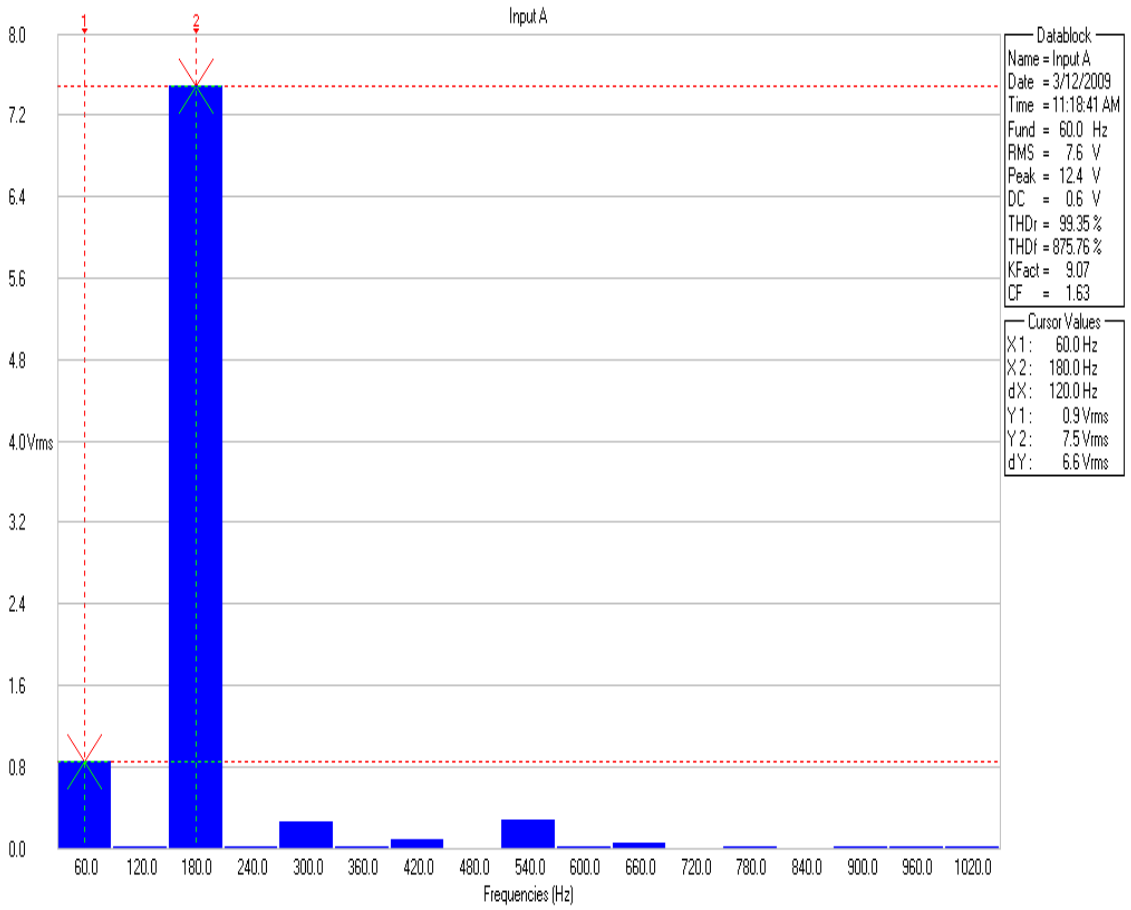
Neutral to Earth (Phase Imbalance) - Oscillography



- No clear peaks and valleys
- Peak and valley values changing

Examples of Voltage Sources

Neutral to Earth (Phase Imbalance) – Harmonic Spectrum



- Dominant Frequency is 180 Hz
- Minimal contributions from other frequencies

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Why is classification important?

- With harmonic content analysis:
  - Avoid making unnecessary repairs
  - Prioritization of Repairs
  - Cost Savings can be achieved
  - System Health can be evaluated

Spreading the word

- NYS Joint Utility Petition to Change NYS PSC Order 04-M-0159
- IEEE Working Group 1695
- IEEE Transaction Papers
  - Using Harmonic Measurements to Aid in Source Determination during Elevated Voltage Investigations
  - The Results of Asset-Based Manual Testing of Utility-Owned Objects for Contact Voltage in New York
- January 2012 T&D World Article

Questions?