# Types of Surge And Related Surge Protection Designs

PQSolutions

Your Source for Power Quality Excellence

**Presented by Tom Butcher, Senior Member IEEE**

# Transient Surge Events

High-energy, fast rise time, short duration

- Energy – Thousands of volts and thousands of amps
- Time & Duration – Nanoseconds to microseconds

***Nanosecond – One billionth of a second***
***Microsecond – One millionth of a second***

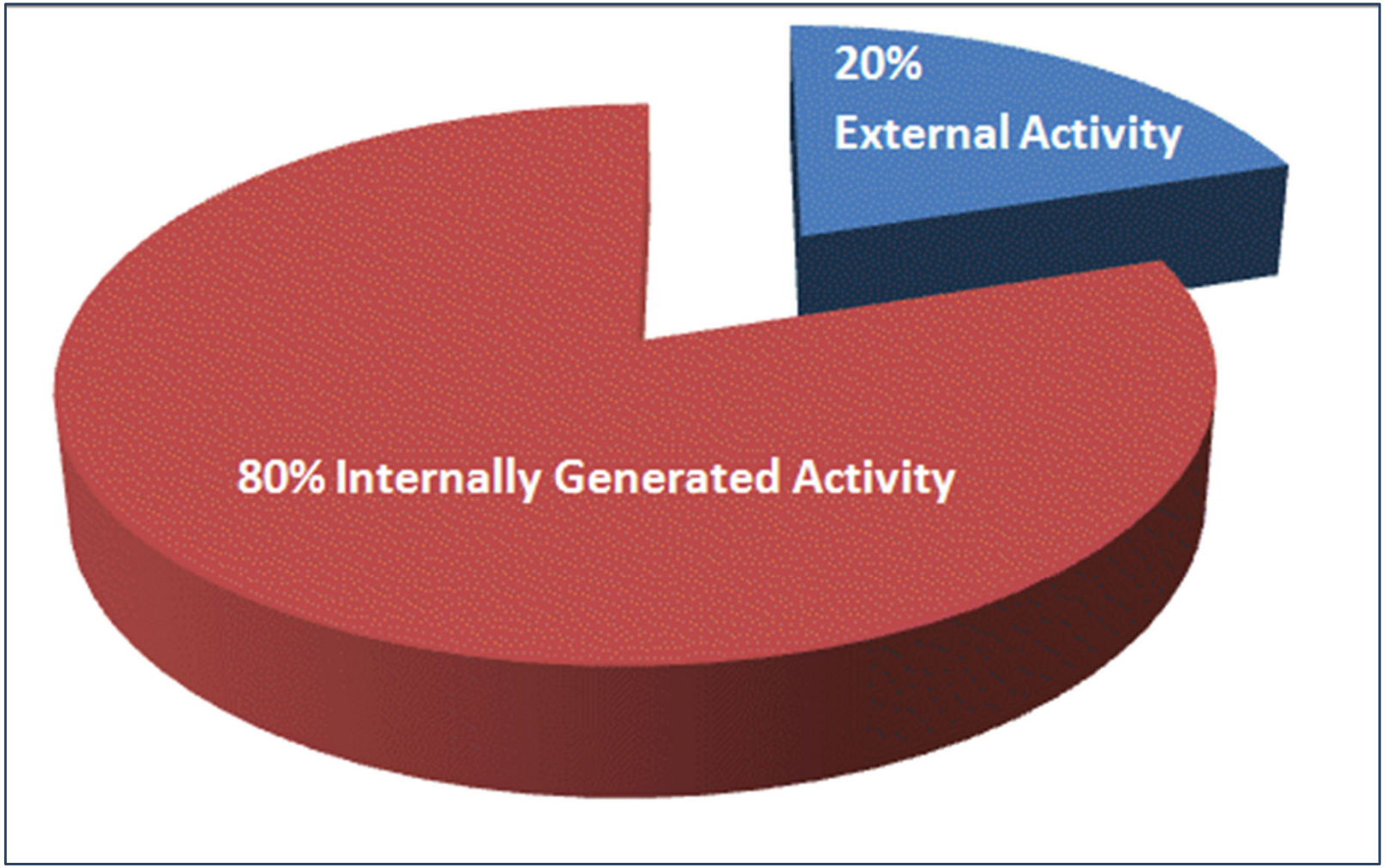
Power Surges travel approximately:

one statute mile in 5.4 µs

**5.4 millionths of a second!**

# Transient Surge Events

(Approximately)

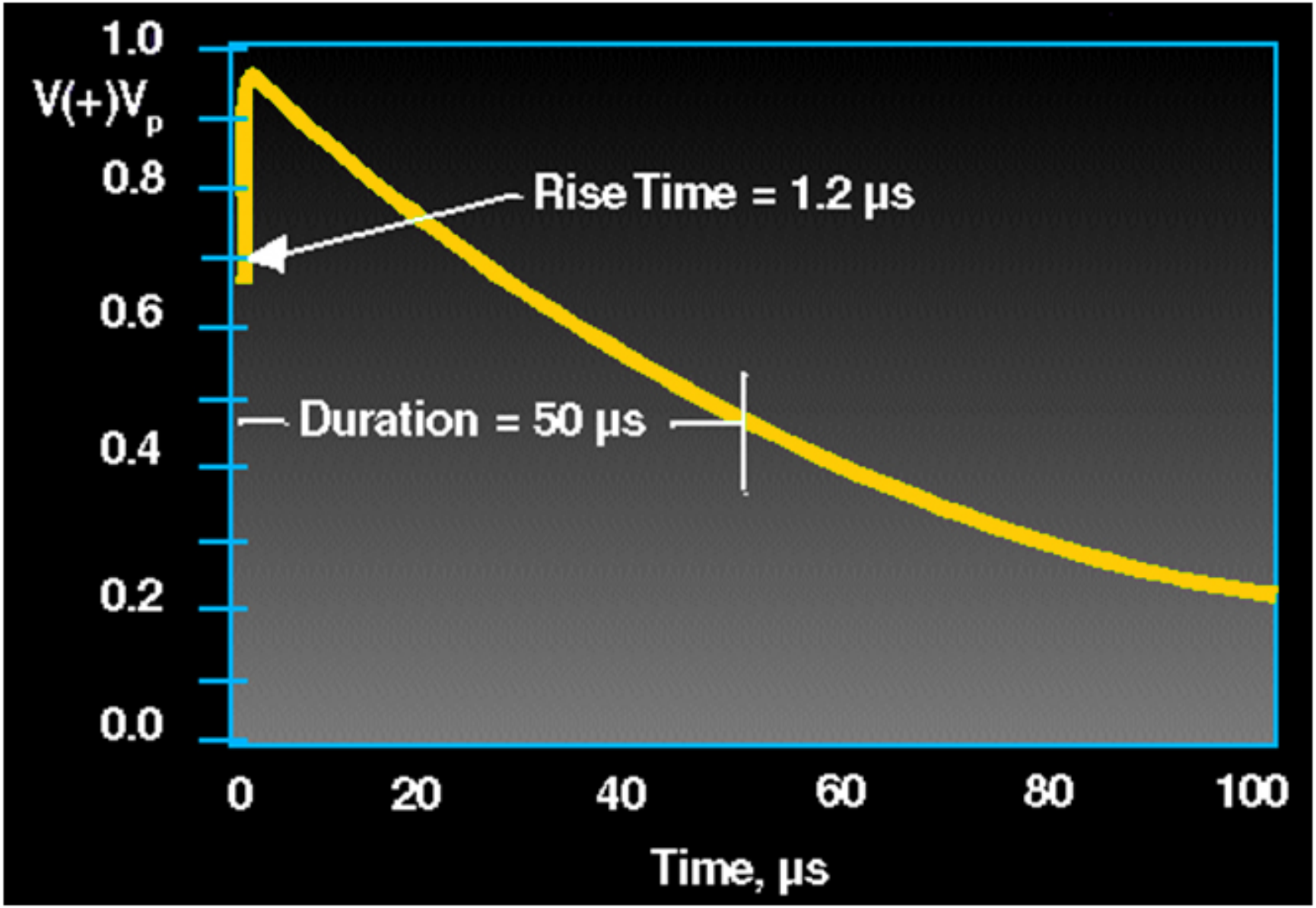



Source: General Electric “Current Scene,” a bulletin of circuit protection technology

Figures based on nationwide averages

# Wave Forms

## Standard Wave Forms Developed by ANSI/IEEE C62.41.2




Combination Wave, Open-Circuit Voltage

# Wave Forms

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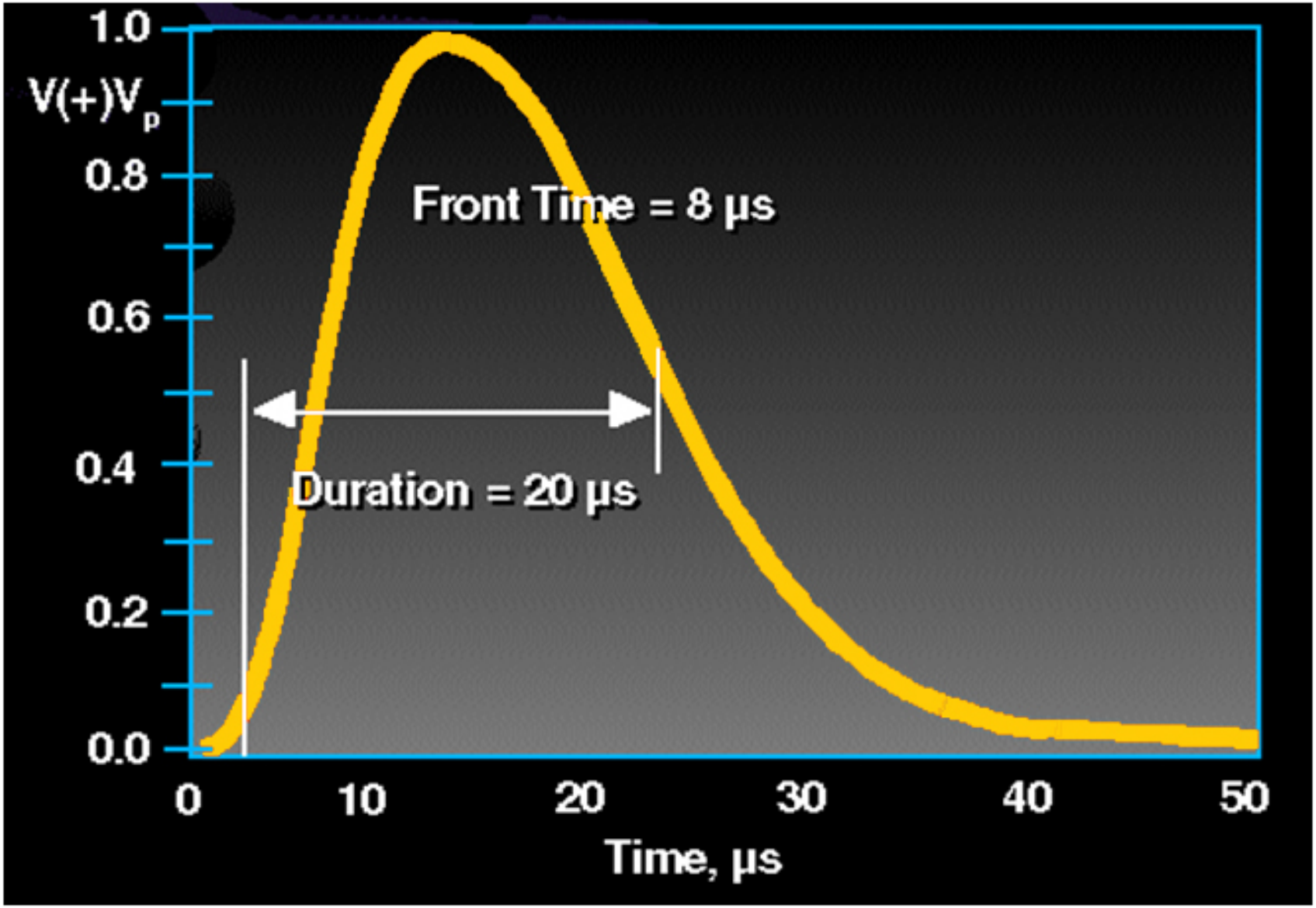
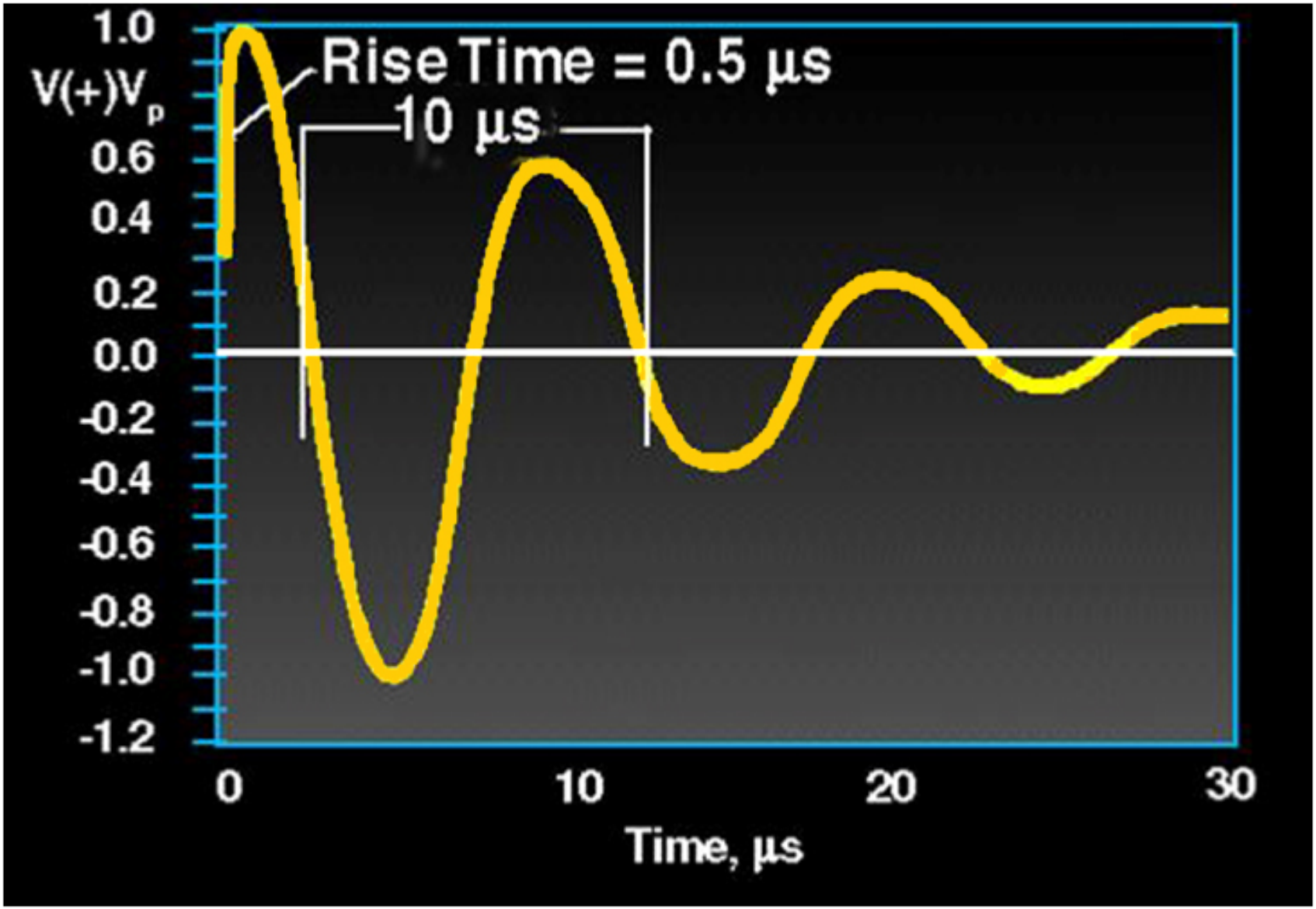



Combination Wave, Short-Circuit Current

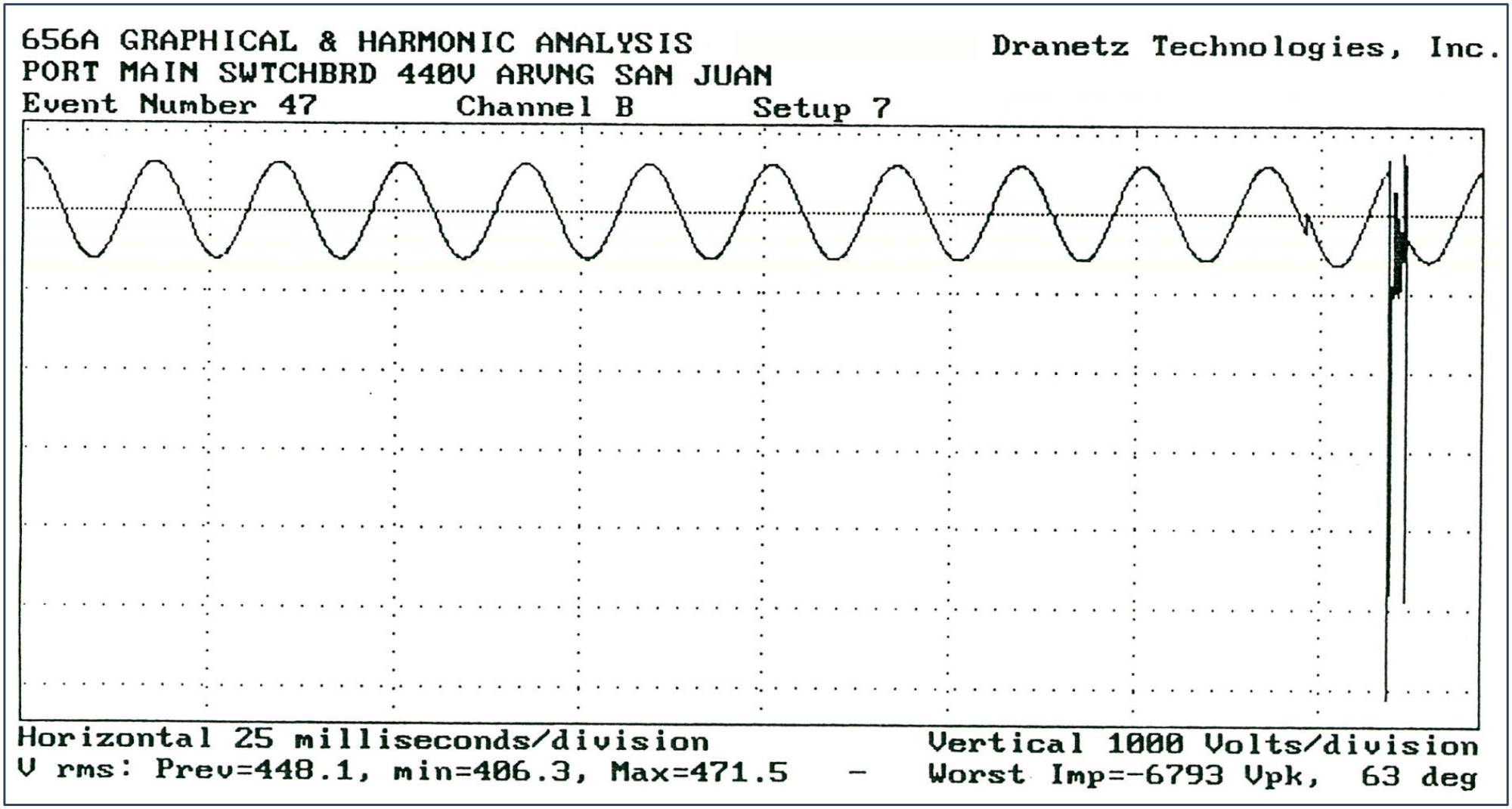
# Wave Forms

## Standard Wave Forms Developed by ANSI/IEEE C62.41.2



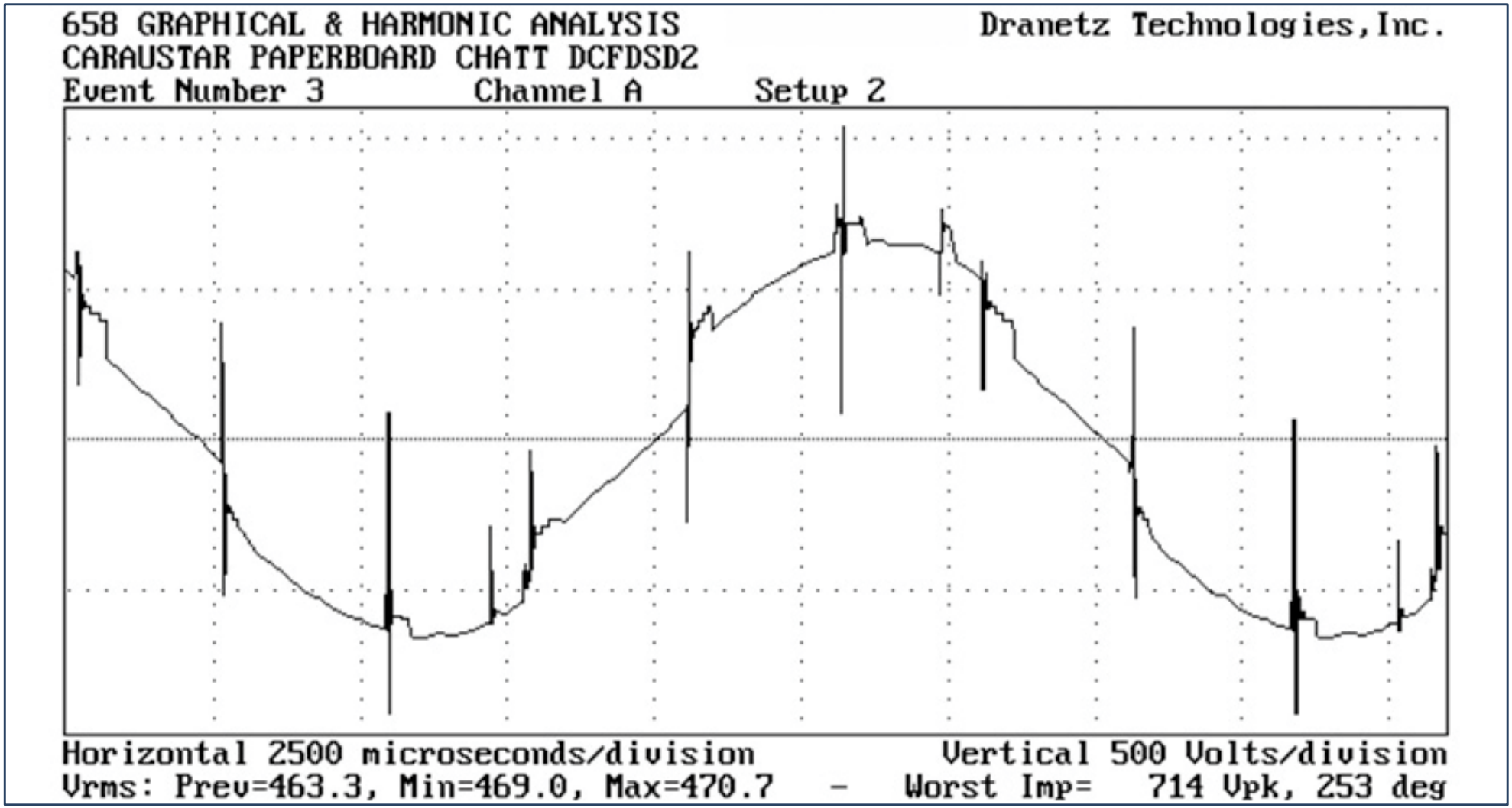

100 kHz Ring Wave

# Main Switchboard Surge



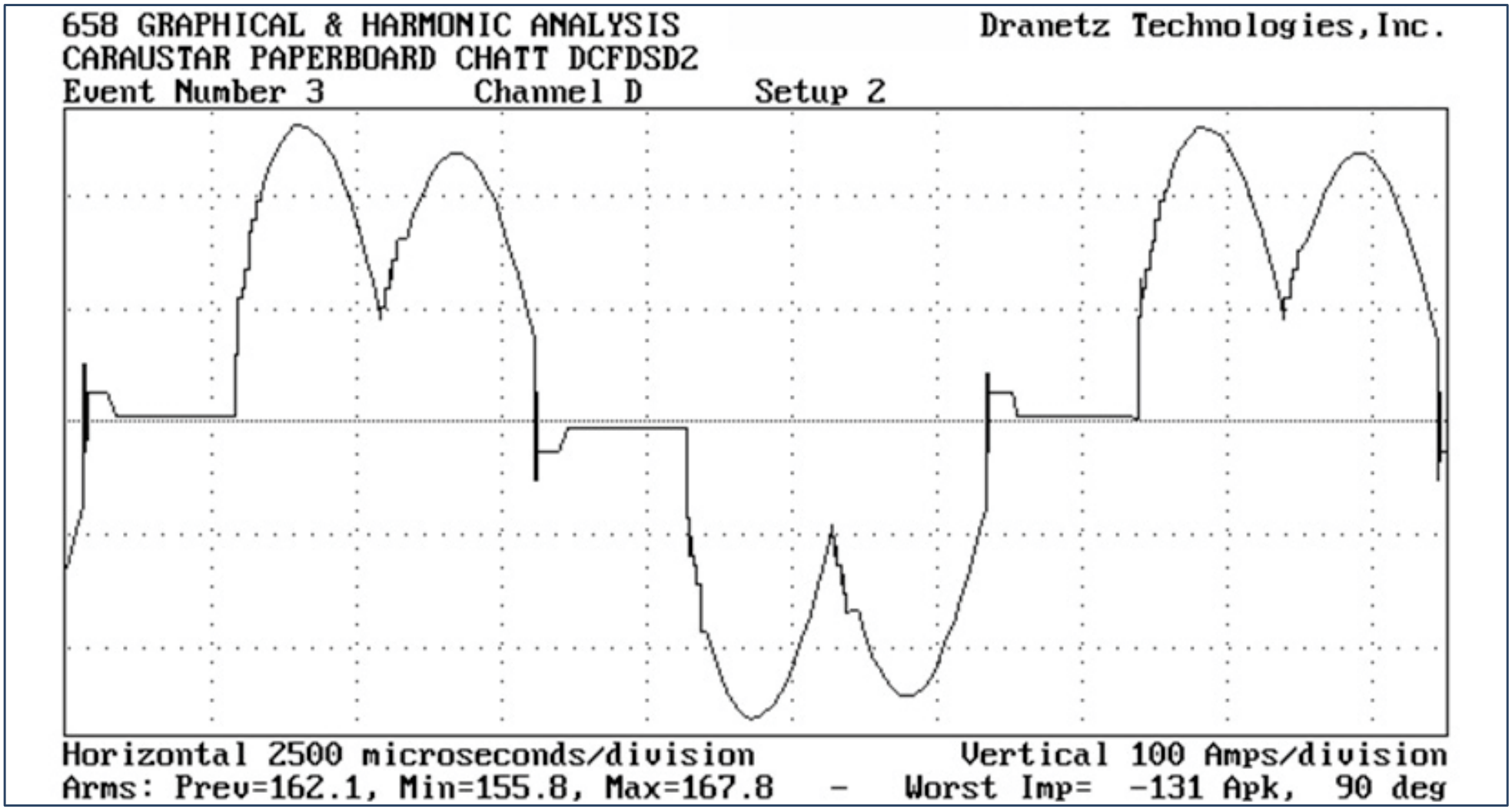

6793 Vpk Transient

# Voltage Surges from 6 Pulse Rectifier

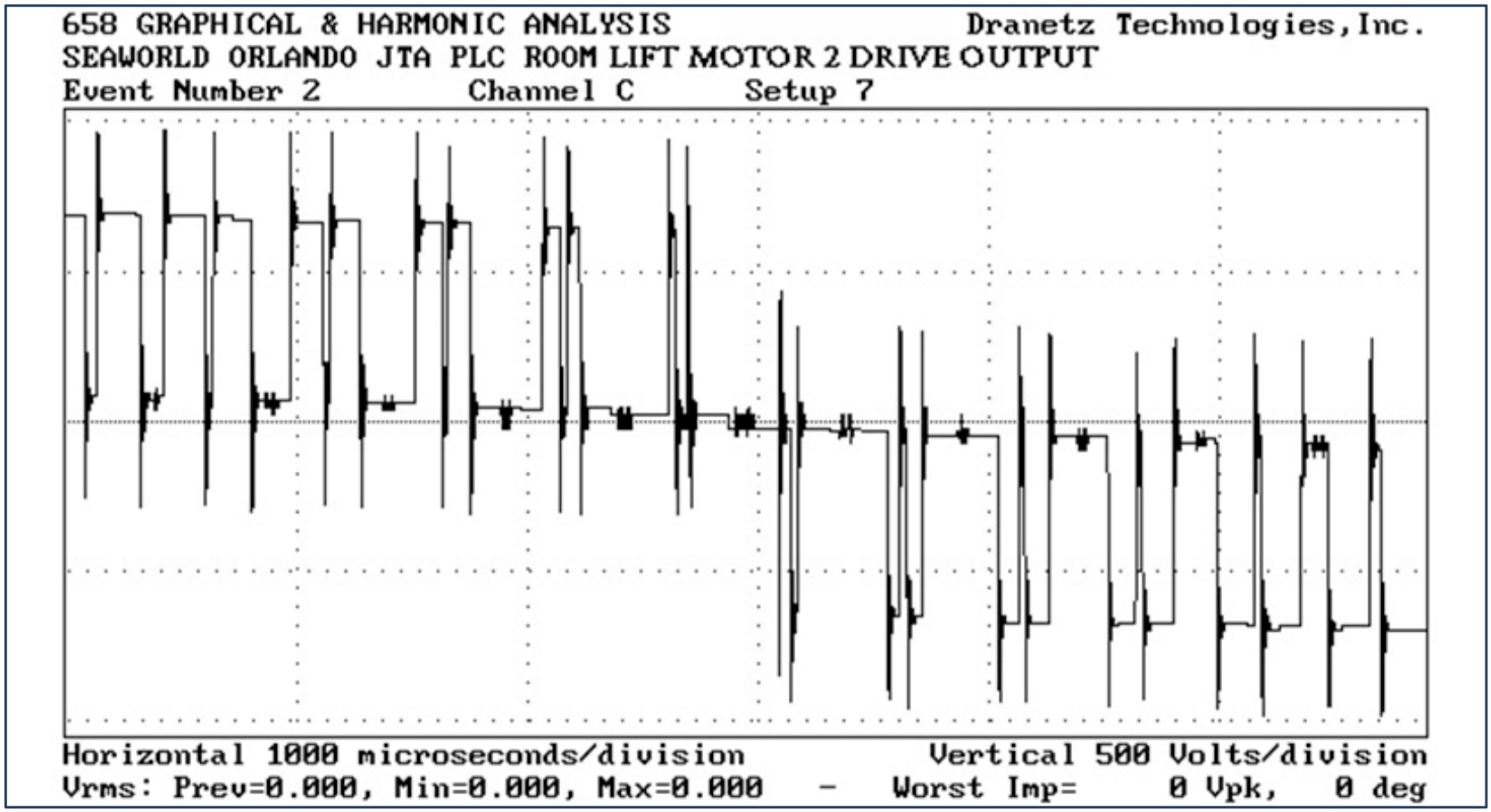



**6 X 60Hz X 60Sec X 60Min = 1,296,000 Surges per Hour**

# Current Distortion from 6 Pulse Rectifier

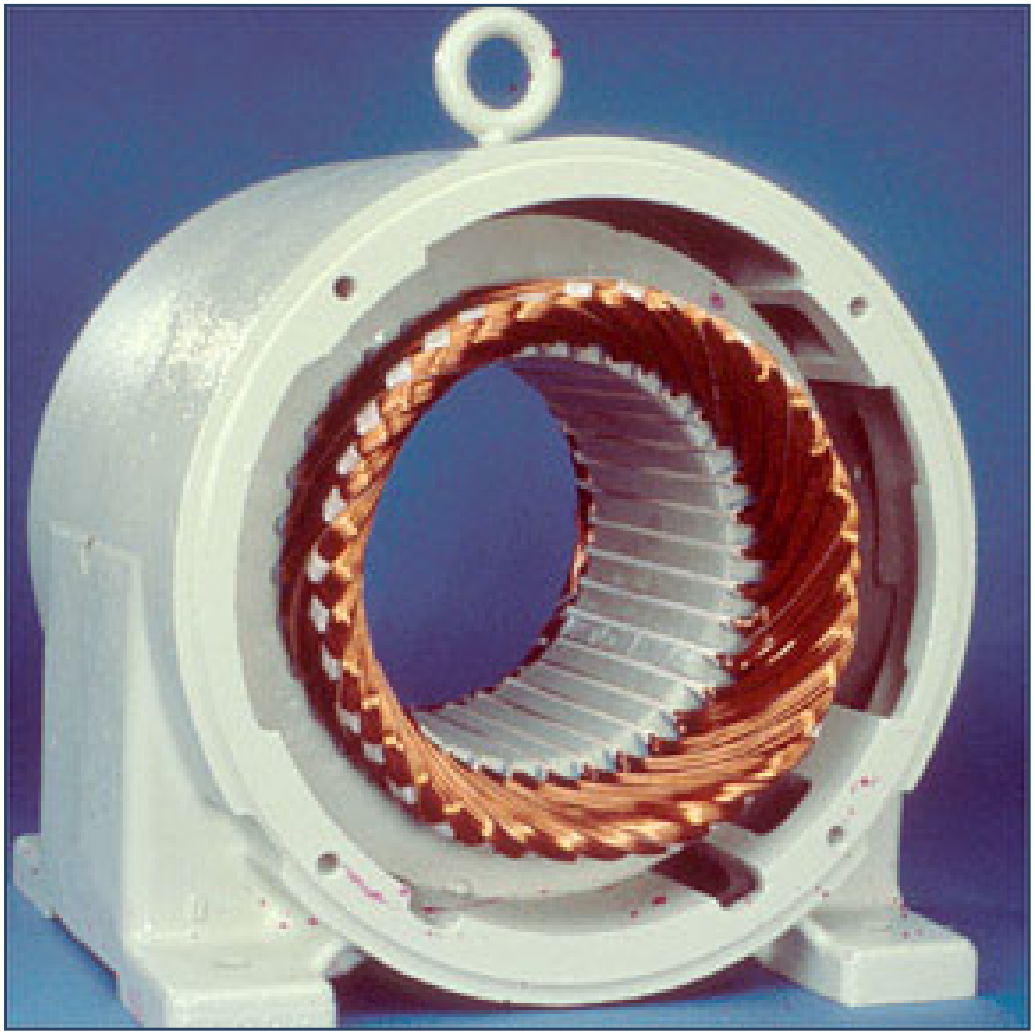


# Voltage Surges from Pulse Width Modulation Drive Cabinet for Lift Motor




48 Pulses/cycle x 2(1 on & 1 off) x 60 cycles x 60 seconds x 60 minutes = **20,736,000** surges/hour

# Typical Causes of Winding Failures in Three-Phase Stator Windings

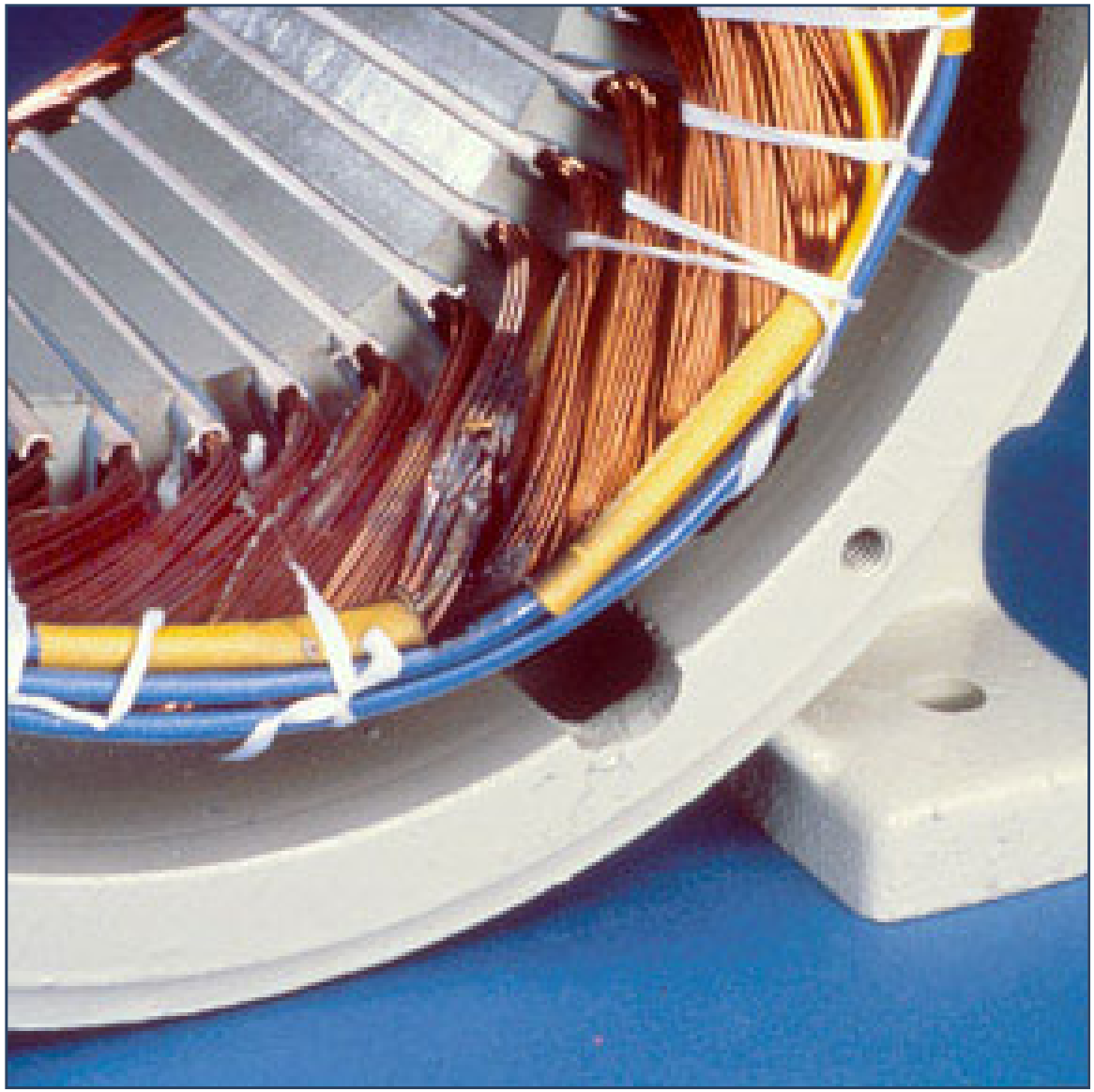


Good Stator Winding

Note: To obtain printed copies of EASA's brochure *Failures in Three-Phase Stator Windings*, see EASA's Price List at www.easa.com, or contact EASA Headquarters by e-mail (easainfo@easa.com), telephone (314-993-2220) or Fax (314-993-1269).

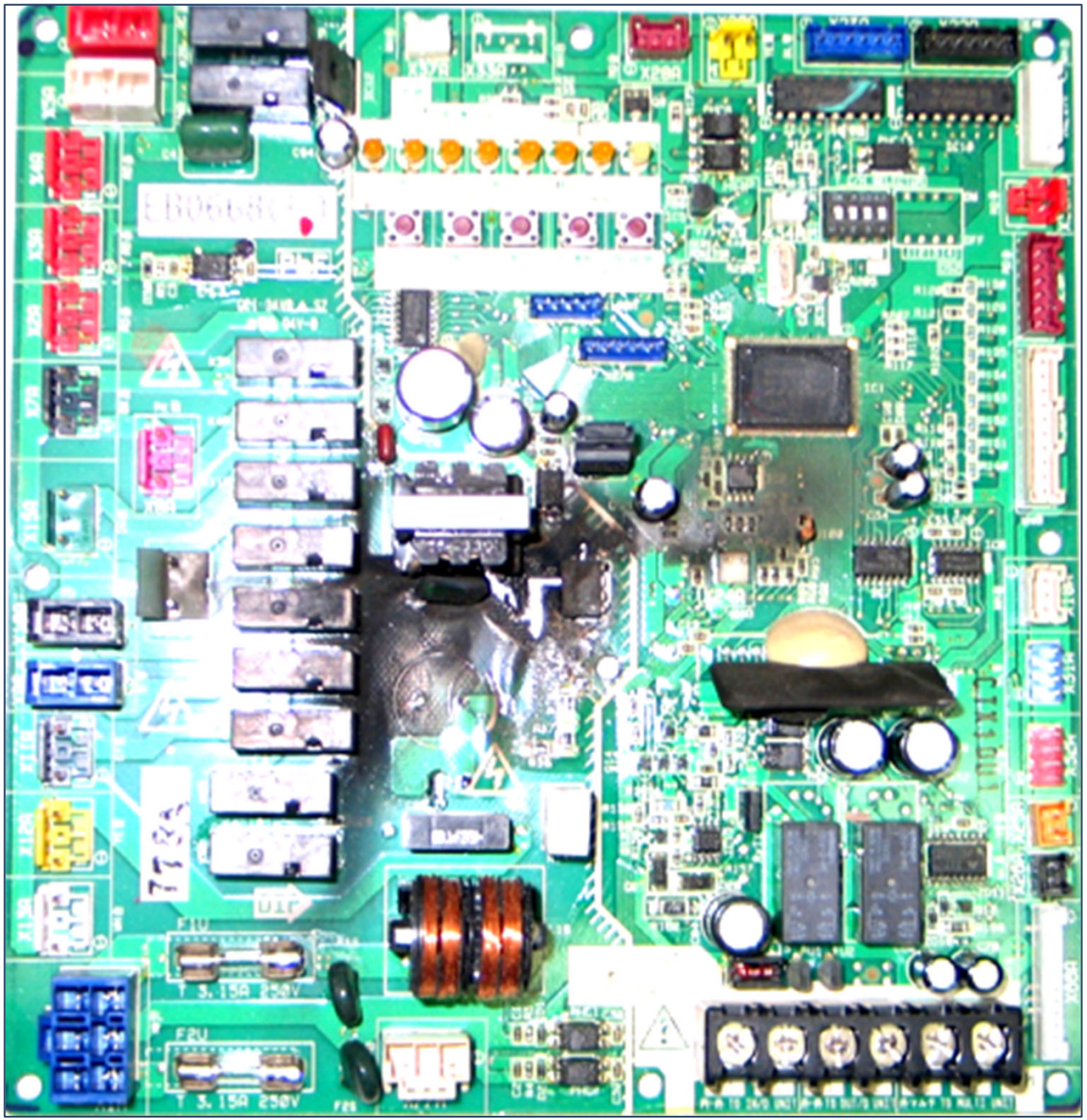
# Typical Causes of Winding Failures in Three-Phase Stator Windings

#12



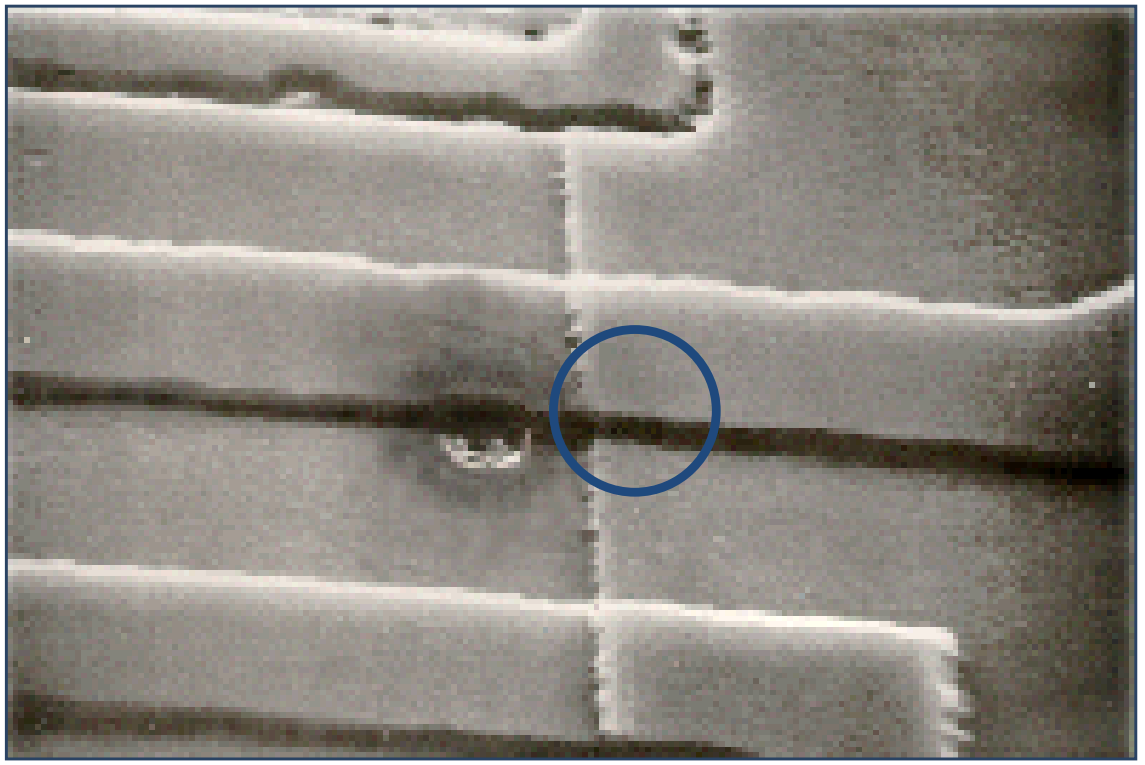
Winding Damaged by Voltage Surge

# Damaged Circuit Board



# Effects Of Surges On Electronic Equipment

The microscopic runs on a processor chip are extremely susceptible to transient related heat stress. The surge meets resistance, converts to heat and causes a blister on the run.



As the repetitive surges continue to “hit the spot”, over time, the blister grows until it effectively blocks the power or data flow on that circuit.

Surges/transients occur in every electrical environment, causing ***catastrophic damage*** as well as ***cumulative damage*** and are routinely dismissed as normal wear and tear on equipment.

# Voltage Responsive Circuitry

*(Threshold, Standard or Fixed Clamping)*

and

# Frequency Responsive Circuitry

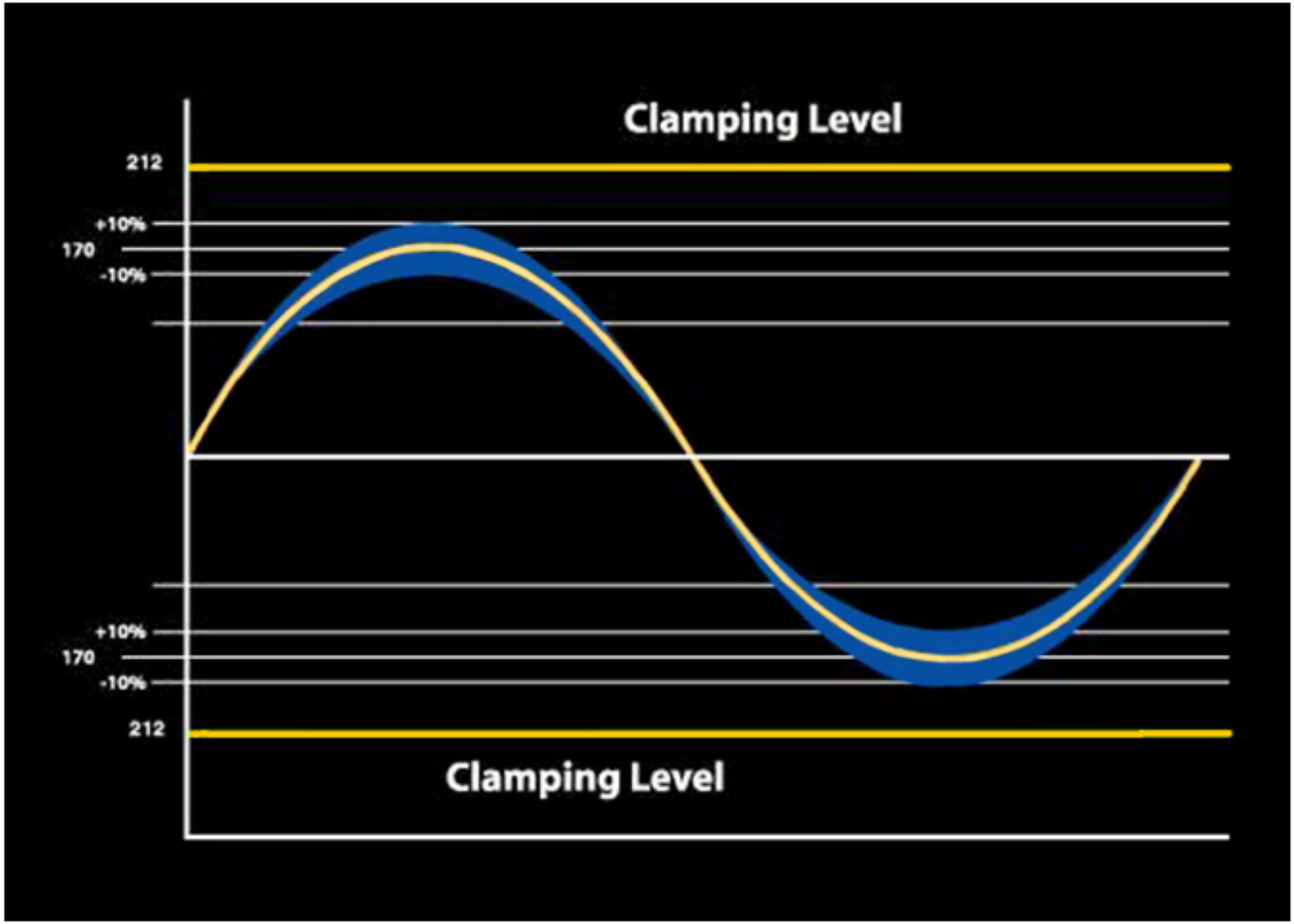
*(Sine Wave Tracking)*

# Voltage Responsive Circuitry

- Requires that a transient **exceed a preset voltage level** above and below the power voltage sine wave before the components within the SPD begin to activate

- Requires **“headroom”** above and below the peak voltage level to prevent the SPD from clamping the power frequency sine wave

# Voltage Responsive Circuitry

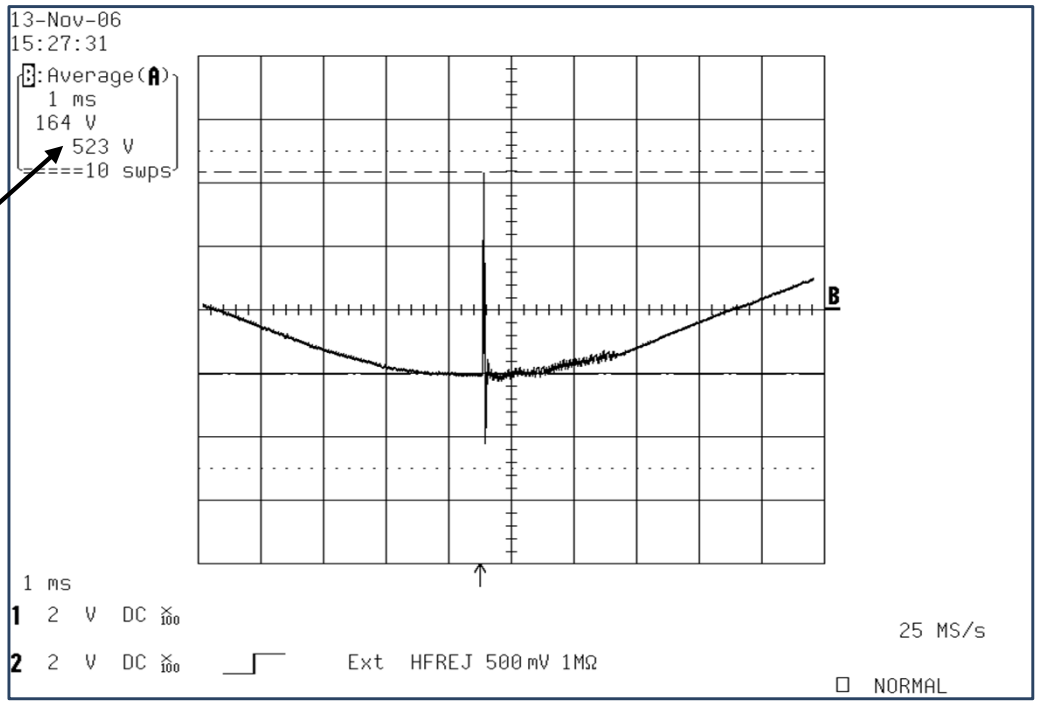



The most effective protection against high-level impulse transients

# Frequency Responsive Circuitry

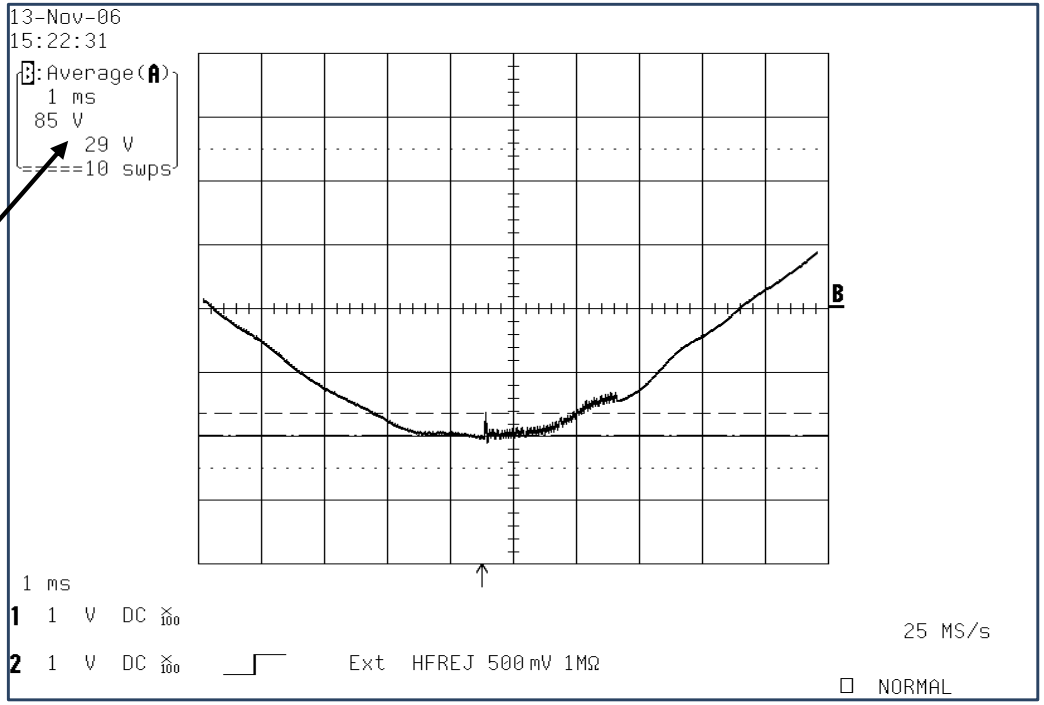
- Designed to address ring wave surges as they deviate from the power frequency sine wave without interaction with the applied power voltage sine wave.
- Unlike the *Voltage Responsive Circuitry*, “headroom” is not required for this type of circuitry to operate.
- Reacts to a **change in frequency** created by the surge.
- Operates independent of the voltage.

# *Voltage Responsive Circuitry vs. Frequency Responsive Circuitry*



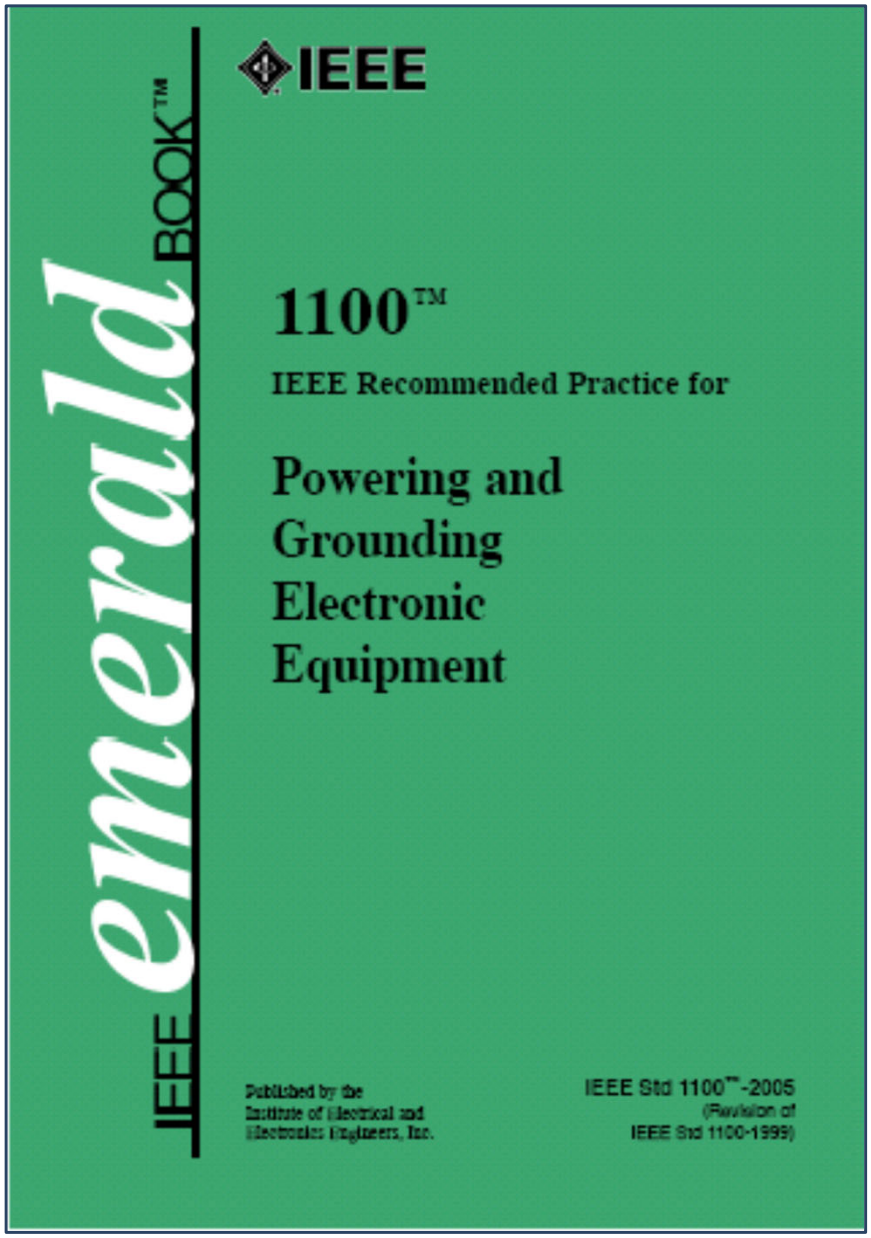

Let-Through
Voltage
523 Volts

A1 Ring Wave
2,000 volts
67 amps
270 degree phase angle




Let-Through
Voltage
29 Volts

# IEEE “Emerald” Book
# Std 1100™-2005



# Lightning/Surge Protection Considerations

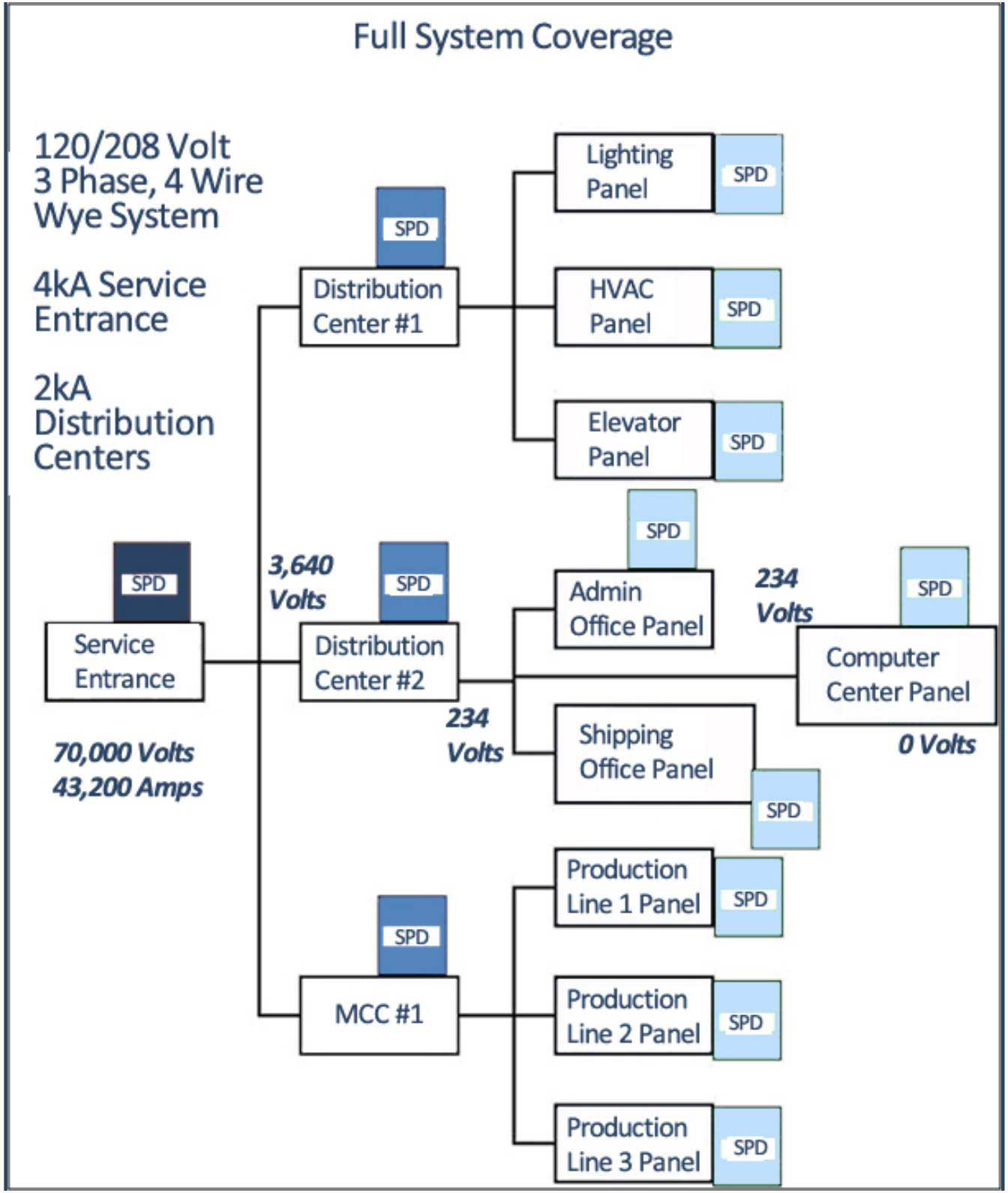
- Large transients originating from outside sources associated with lighting or power system events, are best diverted at the service entrance
- Transients generated within the premises can best be diverted by placing SPDs close to the sources of the transient activity or close to the protected electrical equipment if this is not possible
- ***Best results are obtained if both locations are protected***

IEEE Std 1100-2005, Emerald Book, Section 8.6

# Premise Electrical System Surge Protection

- In addition to the installation of a surge protective device at the ***service entrance***, it is recommended that surge protective devices rated for Category B or Category A, as specified in IEEE C62.41.2, be applied to ***downstream electrical switchboards and panelboards***
- And on panelboards of separately derived power systems that service connected information technology equipment (ITE), signaling, television, and other forms of electronic load equipment

IEEE Std 1100-2005, Emerald Book, Section 8.6.4



*THANK YOU*

*FOR*

*YOUR TIME*

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