

**Power Quality  
Who's Responsible -  
Utility or Facility**

**Powercare III  
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# Presentation Overview

- ◆ **Power Quality Issues**
- ◆ **Impact of Power Quality**
- ◆ **Equipment Tolerances**
- ◆ **Field Measurements**
- ◆ **Mitigation Techniques**
- ◆ **Harmonics**
- ◆ **Conclusions**

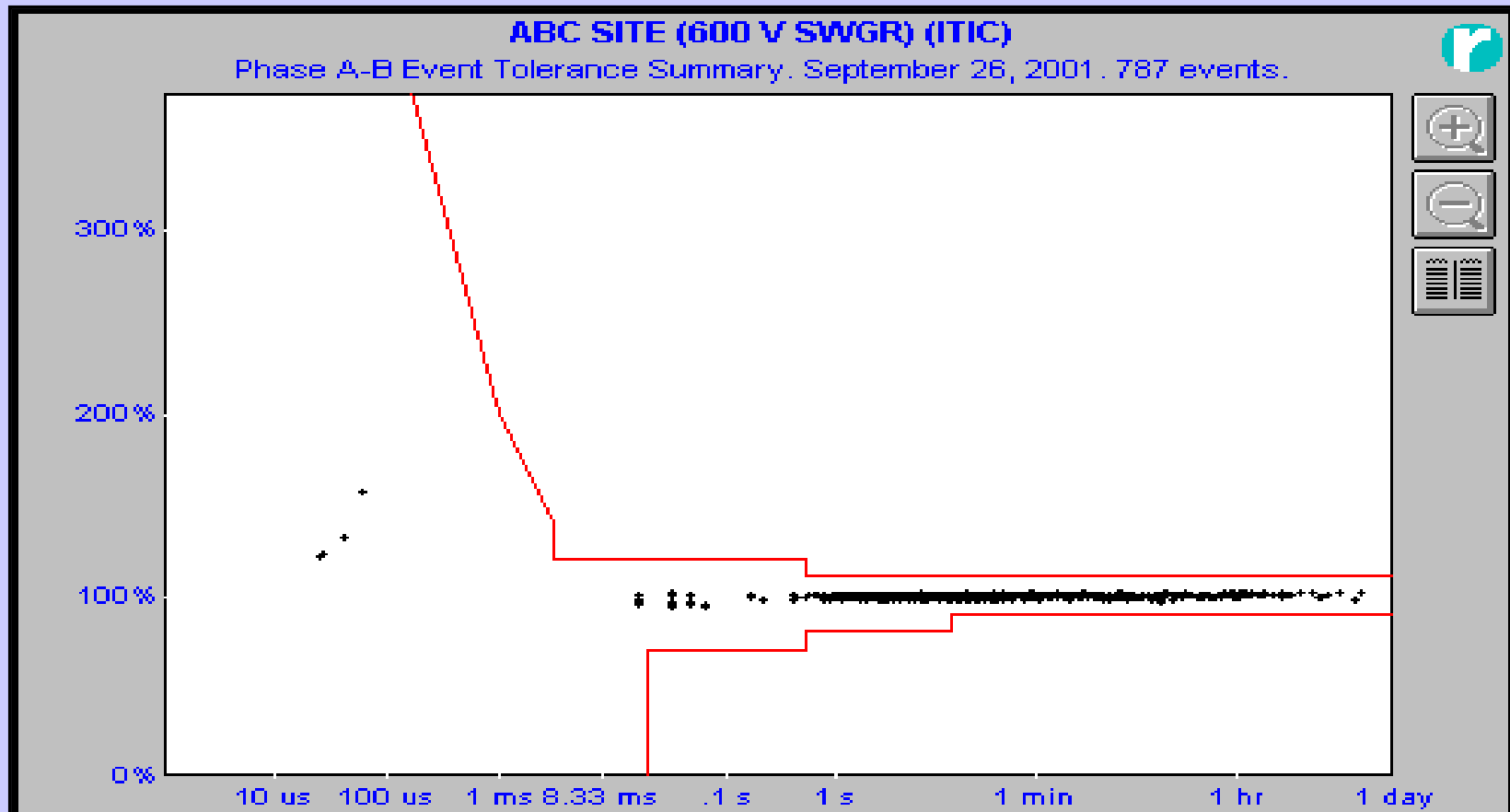
# Power Quality Issues

- ◆ **Power Quality Voltage Disturbance Problems are of Increasing Concern**
- ◆ **Modern Equipment is More Sensitive to Voltage Sags**

# **Equipment Sensitive to Power Quality**

- ◆ **Industrial Power Electronic Equipment including Variable Frequency Drives**
- ◆ **Computer Systems, Process Monitoring and Control**
- ◆ **Electronic Process Control, Such as PLC**
- ◆ **Telecommunications**
- ◆ **Robotics**

# Modified CBEMA Curve



# Cost Of Power Quality

- ◆ **US Estimates of Industrial Cost is multi-billion \$ per annum**
- ◆ **Up to \$2 Million per Incident in Some Cases**
- ◆ **It is Estimated that within 5-10 Years the Majority of Power Consumed in the US will be Converted in Some Way by Power Electronics**

# **What is the Primary Problem ?**

- ◆ **Voltage Sags have been Identified as being the Single Most Expensive Power Quality Event.**
- ◆ **Both Industrial and Commercial Facilities are Affected by this Type of Problem.**

## Voltage Sags

- ◆ **Average US Plant has About 66 Sags/Year**
- ◆ **Cost per Sag \$6-\$40 per KVA/Event**
- ◆ **Estimated Sag Cost is \$20K for 500 KVA System**
- ◆ **Lost Production, Wasted Product, Possible Equipment Damage, Restart Time and Associated Labour**

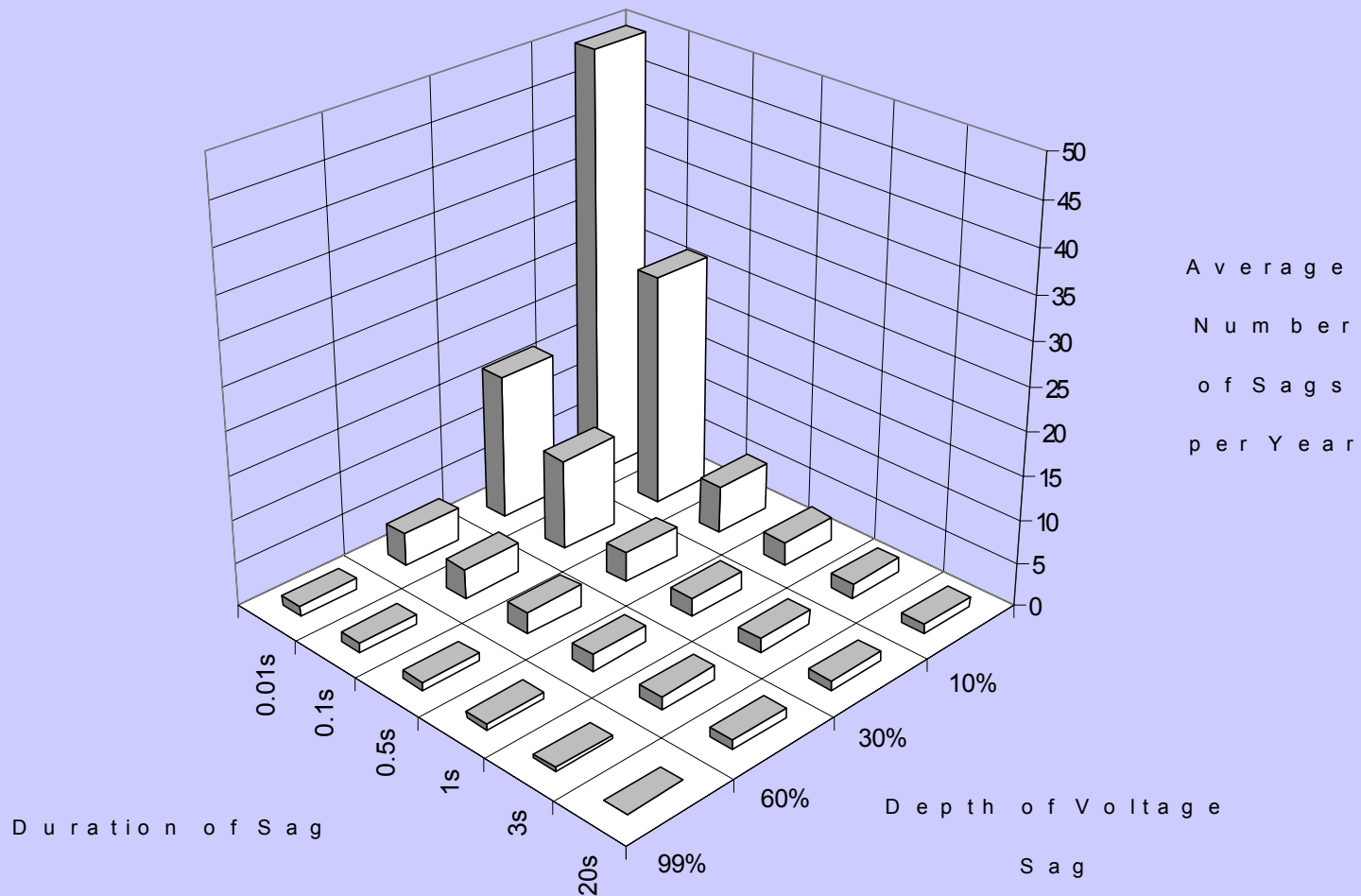


# Source of Voltage Sag

## Sags are Mainly Caused By:

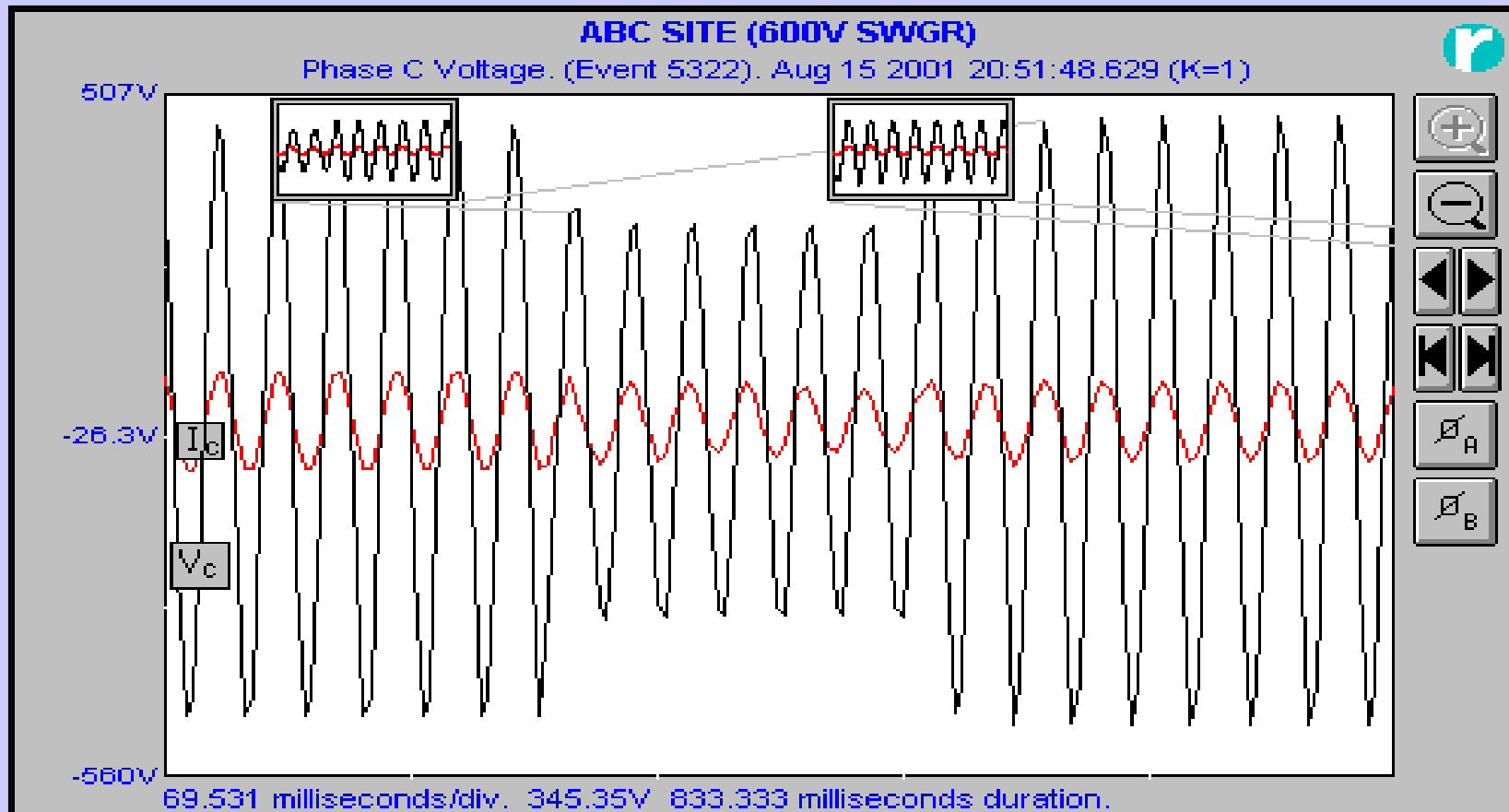
- ◆ **External - Network Problems**  
**EX: Feeder, Transformer Faults, etc**
- ◆ **Internal - In Plant Load Switching**  
**EX: Motor Starting**
- ◆ **For Every Utility Outage, There are 8 or More Large Sags.**
- ◆ **Most Sags are about 30% Voltage Reduction from Nominal.**

# Typical Utility Events / Year





# Voltage Sag of 35% for 120 Ms



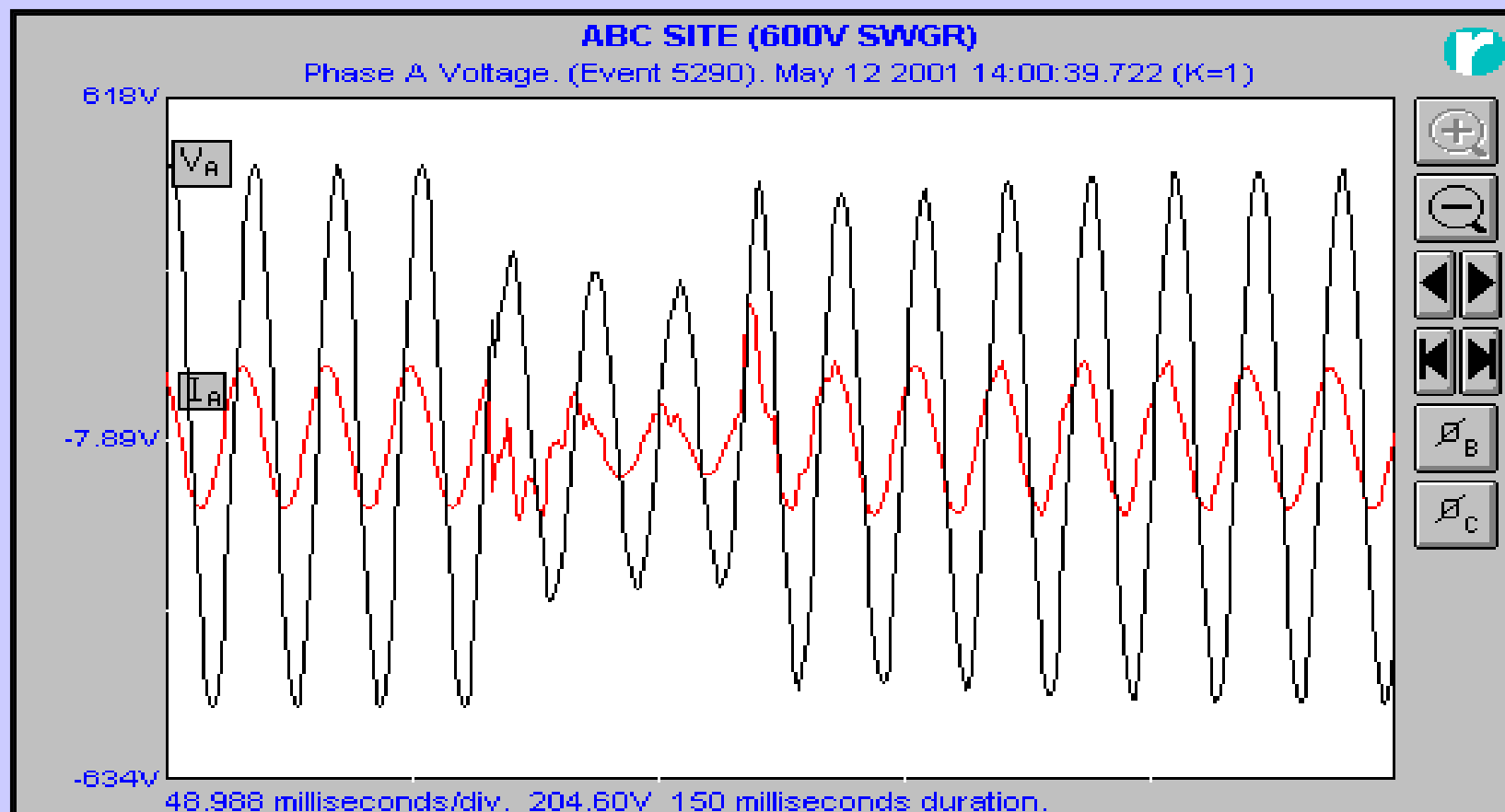
# UPS Alarm History

0033 08/15/01 20:50:59.05.1 UPS Normal  
0034 08/15/01 20:50:58.37.1 rct current available  
0035 08/15/01 20:50:54.59.1 rectifier normal  
0036 08/15/01 20:50:29.45.1 UPS summary alarm  
0037 08/15/01 20:50:29.26.2 rct in current limit  
0038 08/15/01 20:50:29.26.1 rct in recharge  
0039 08/15/01 20:50:29.20.1 input voltage normal

**0040 08/15/01 20:50:29.16.1 input voltage low**

0041 08/01/01 19:20:13.55.0 UPS Normal

# Voltage Sag 50%- UPS Crashed Bad Battery Cell



# UPS Alarm History

**0123 05/12/01 14:00:09.11.1 sbs on**

**0124 05/12/01 14:00:09.11.1 inverter off**

**0125 05/12/01 14:00:09.10.2 dc low shutdown**

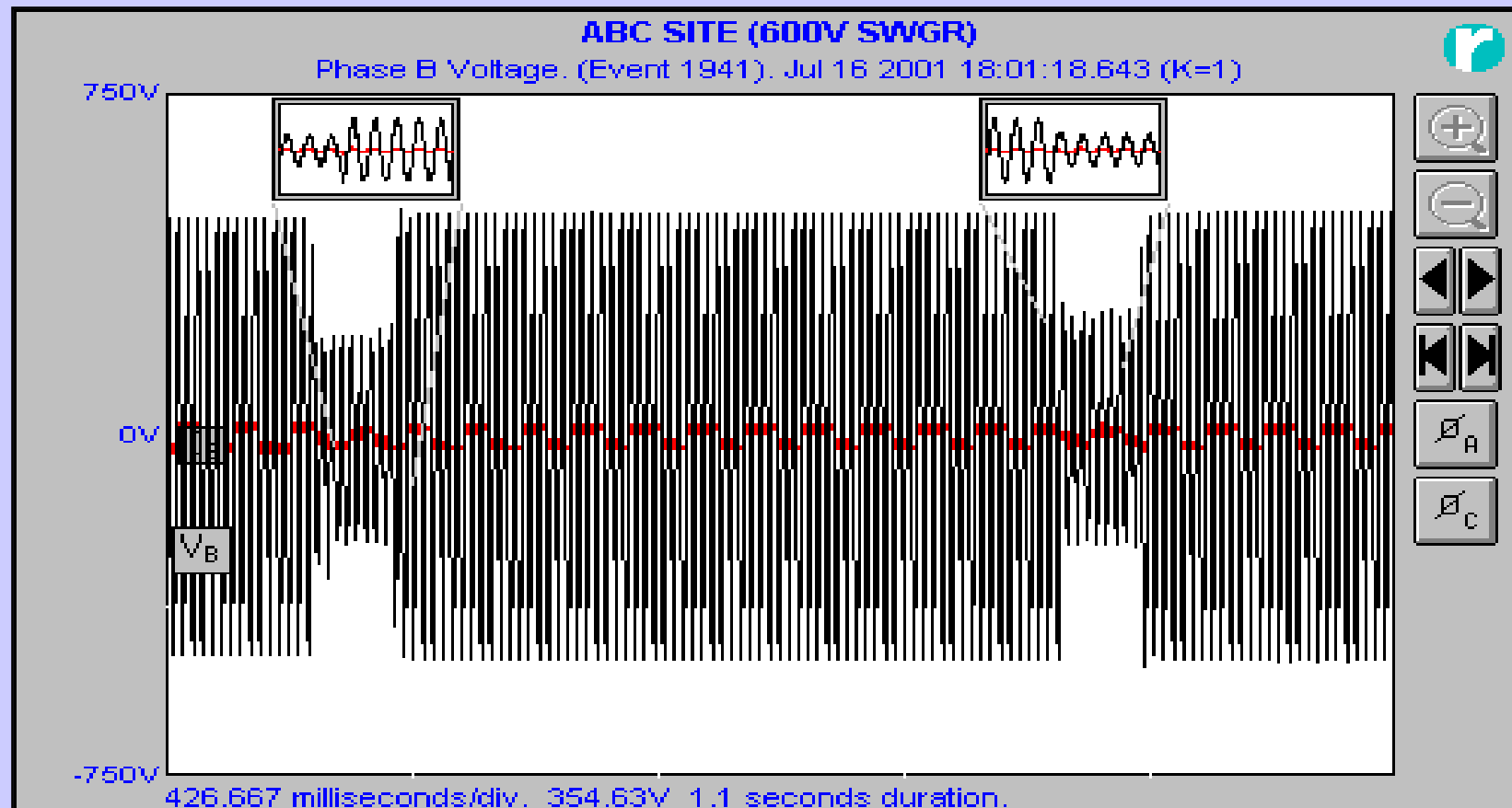
**0126 05/12/01 14:00:09.10.2 dc voltage low**

**0127 05/12/01 14:00:09.10.1 input voltage normal**

**0128 05/12/01 14:00:09.09.2 battery voltage low**

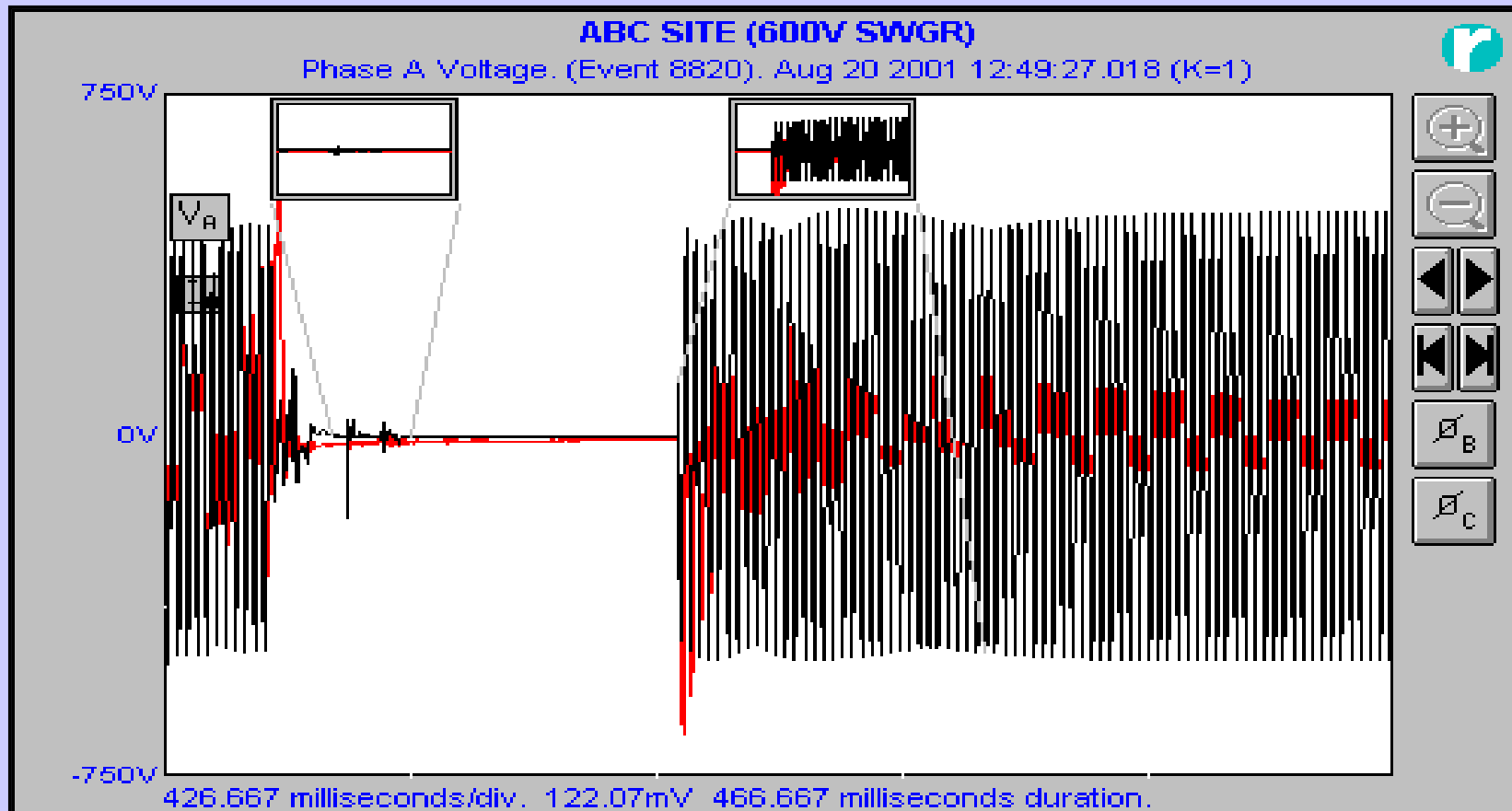
**0129 05/12/01 14:00:09.08.1 input voltage low**

# Two Voltage Sags of 50% within One Second





# Momentary Loss of Power - 730 Ms.



# UPS Alarm History

0022 08/20/01 12:48:02.21.2 input voltage normal

0023 08/20/01 12:48:02.11.2 input frequency normal

**0024 08/20/01 12:48:00.29.2 UPS pwr supply inp normal**

0025 08/20/01 12:48:00.09.2 UPS summary alarm

0026 08/20/01 12:47:59.51.2 UPS pwr supply inp failure

0027 08/20/01 12:47:59.50.3 UPS pwr supply inp normal

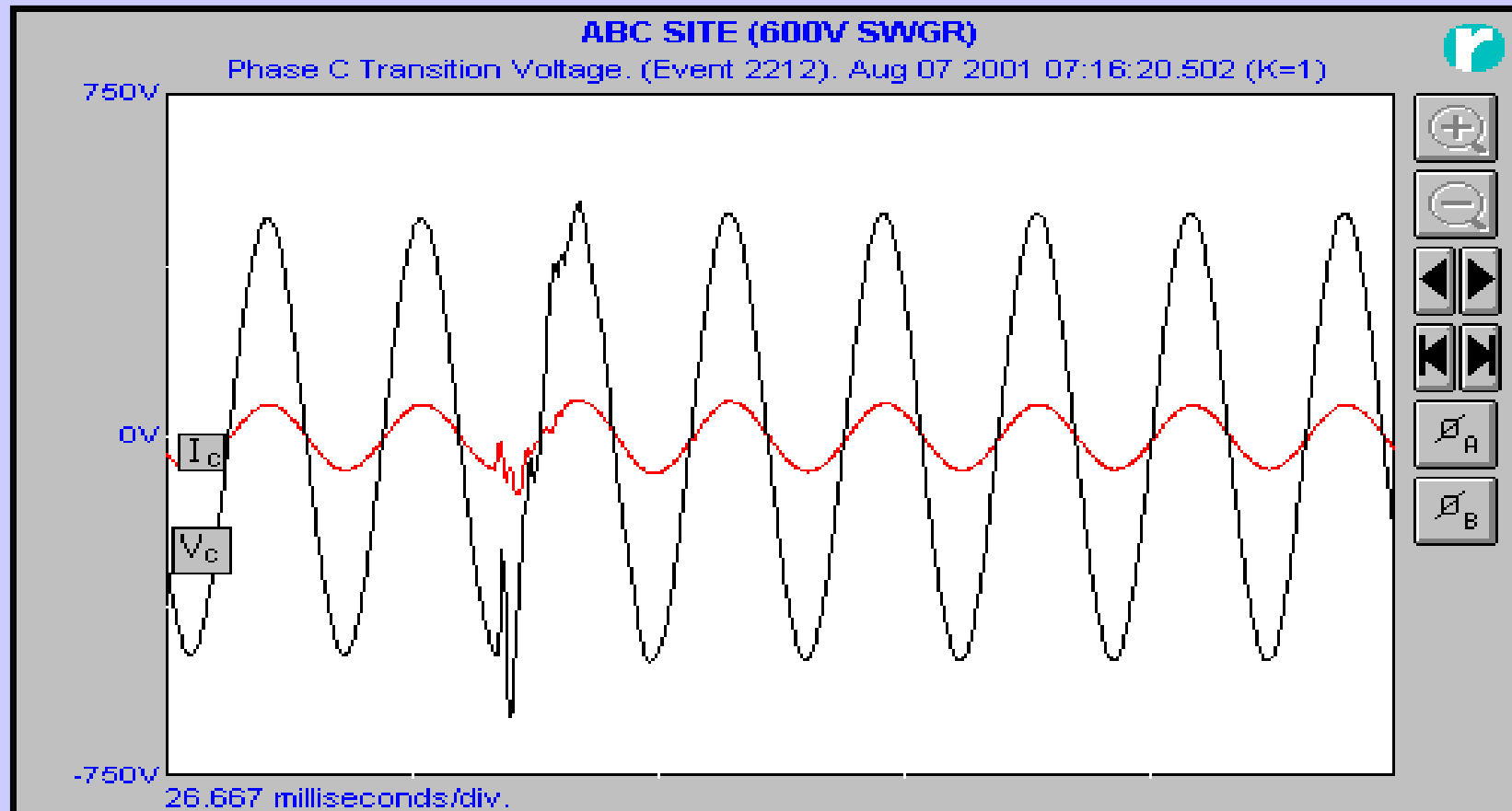
**0028 08/20/01 12:47:59.50.2 UPS pwr supply inp failure**

0029 08/20/01 12:47:59.49.3 rct not phase locked

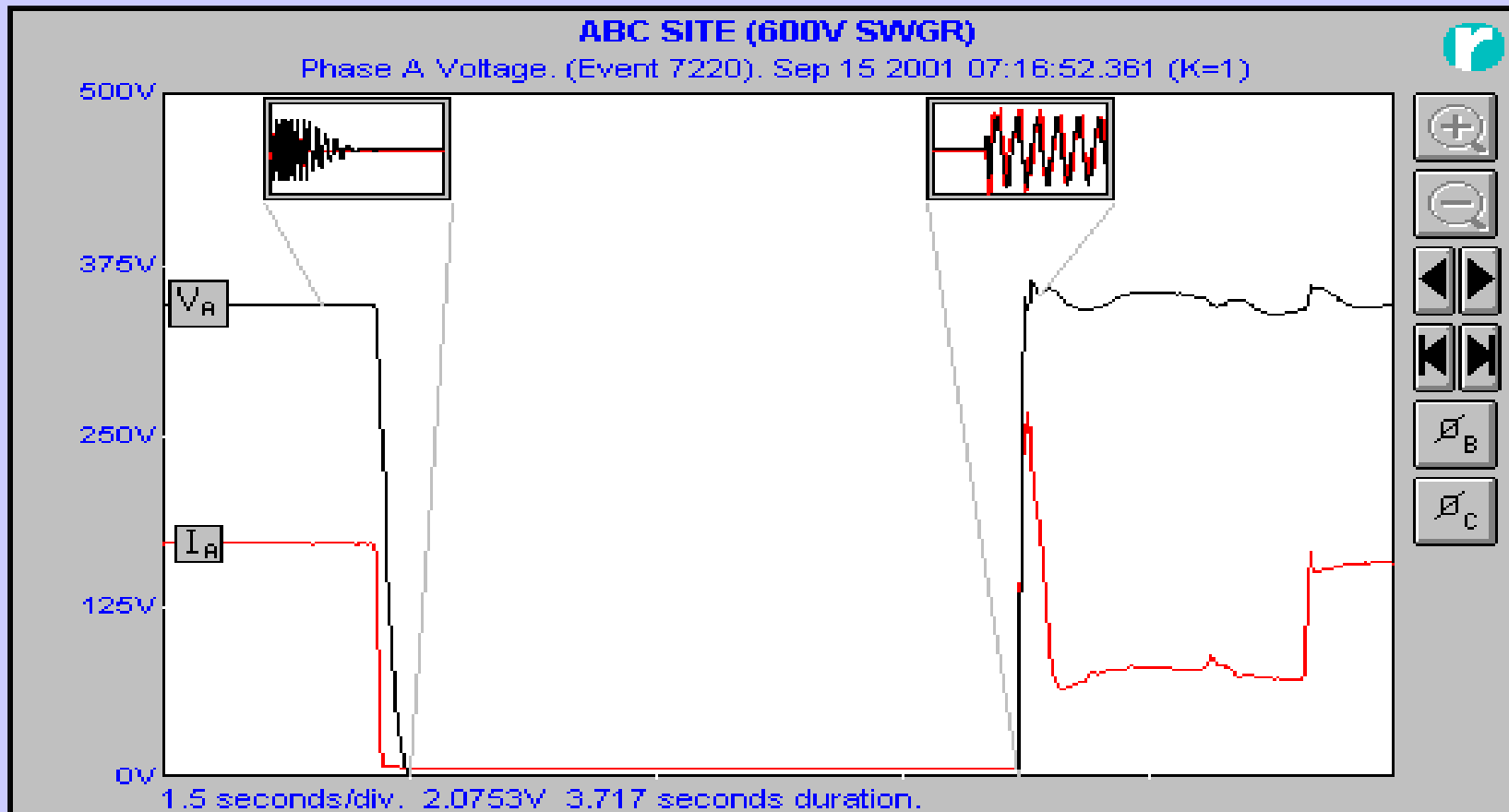
0030 08/20/01 12:47:59.49.3 input frequency low

0031 08/20/01 12:47:59.46.2 input voltage low

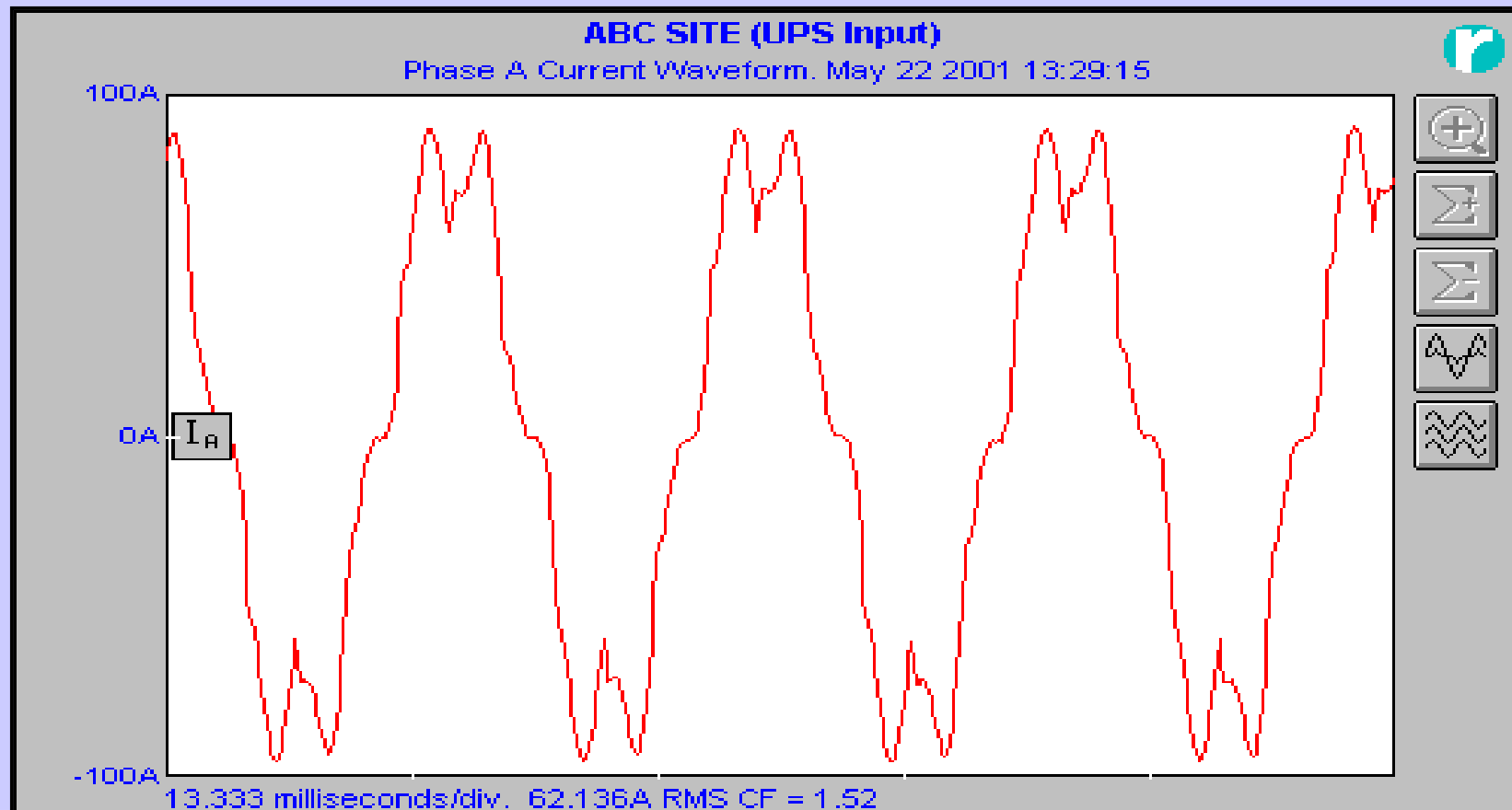
# Utility Capacitor Switching



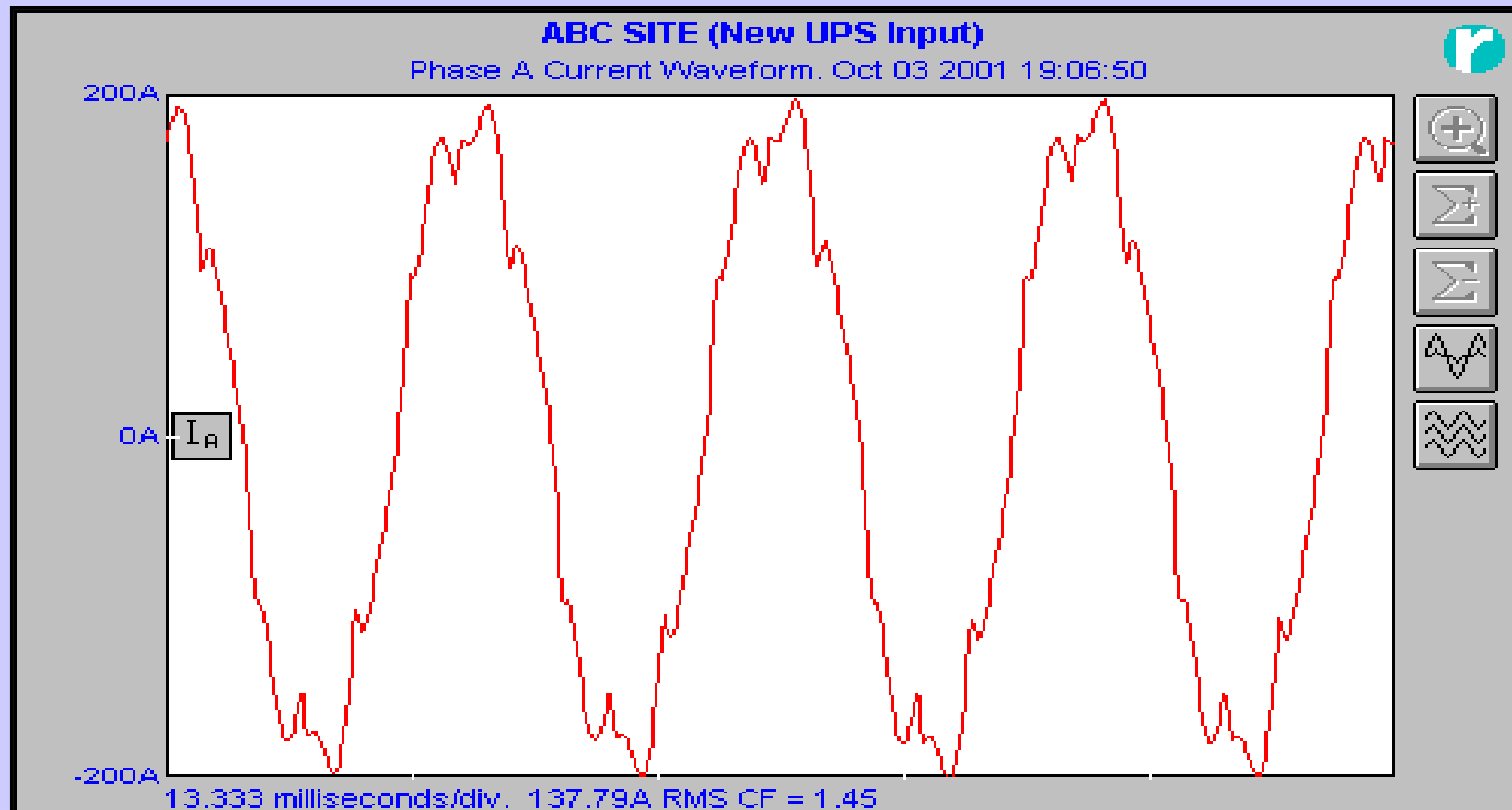
# Starting Generator - 4 Sec.



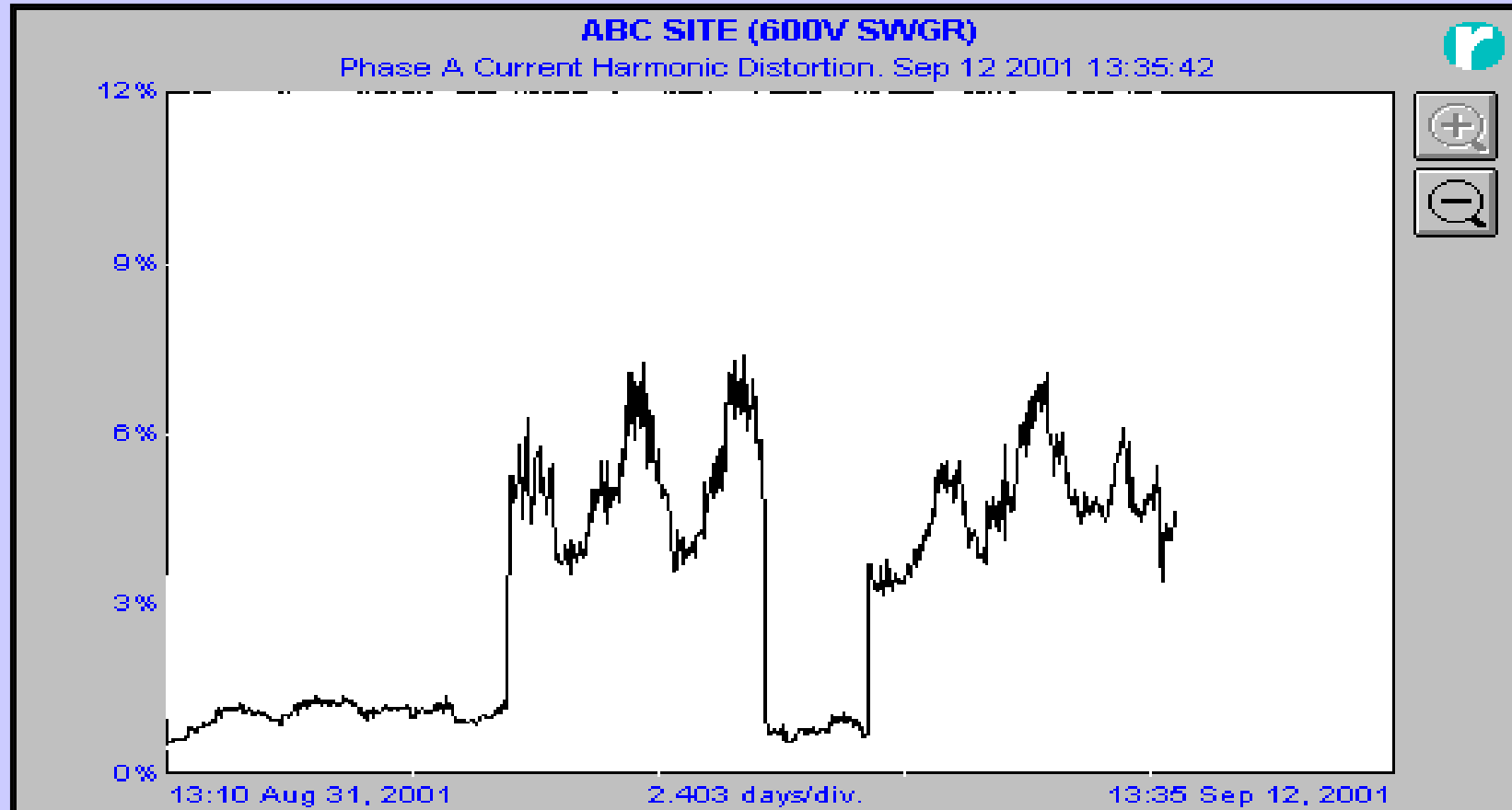
# UPS Input Current Waveform without Input Filter



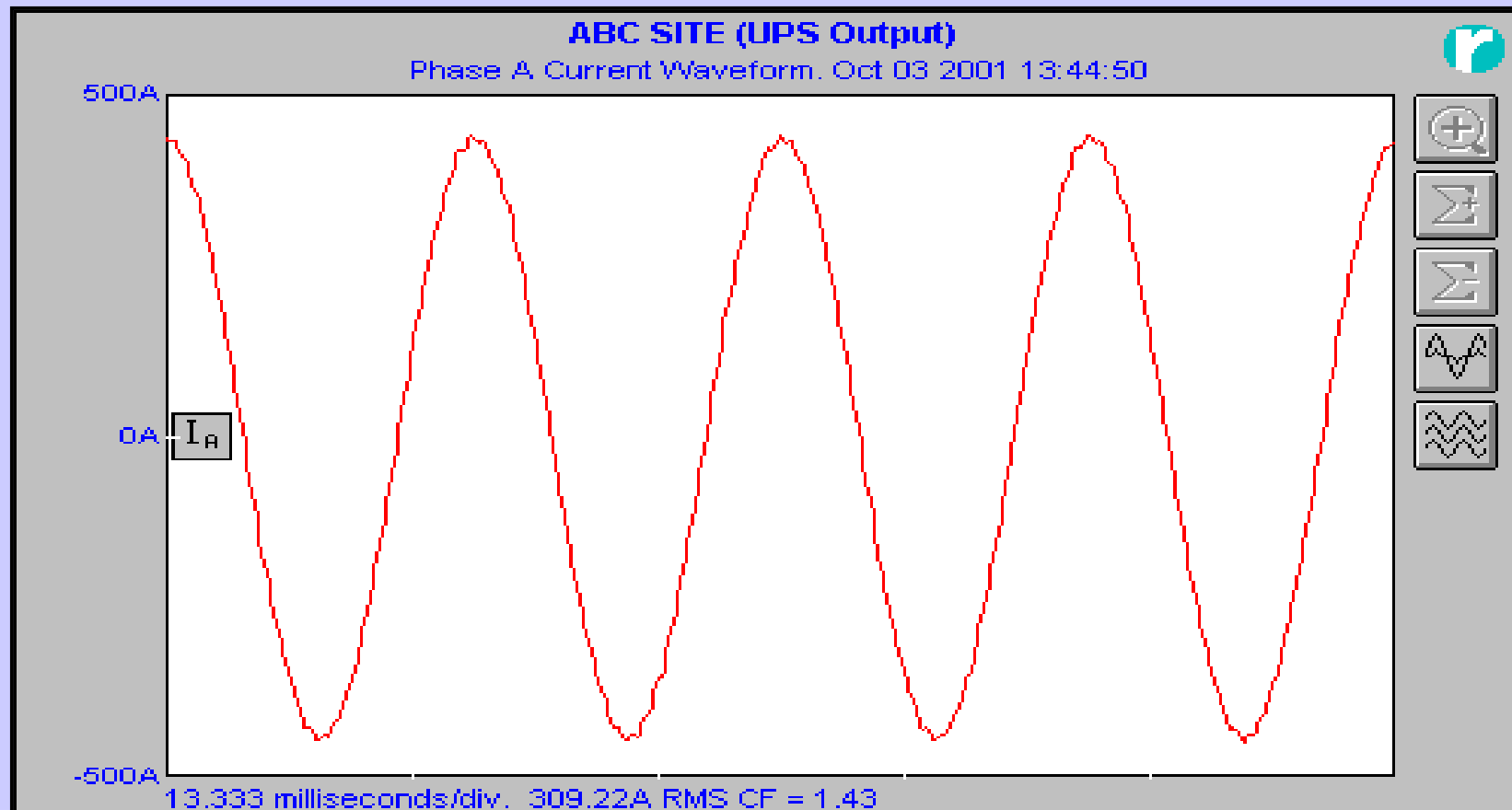
# UPS Input Current Waveform with Input Filter



# Active Filter Performance

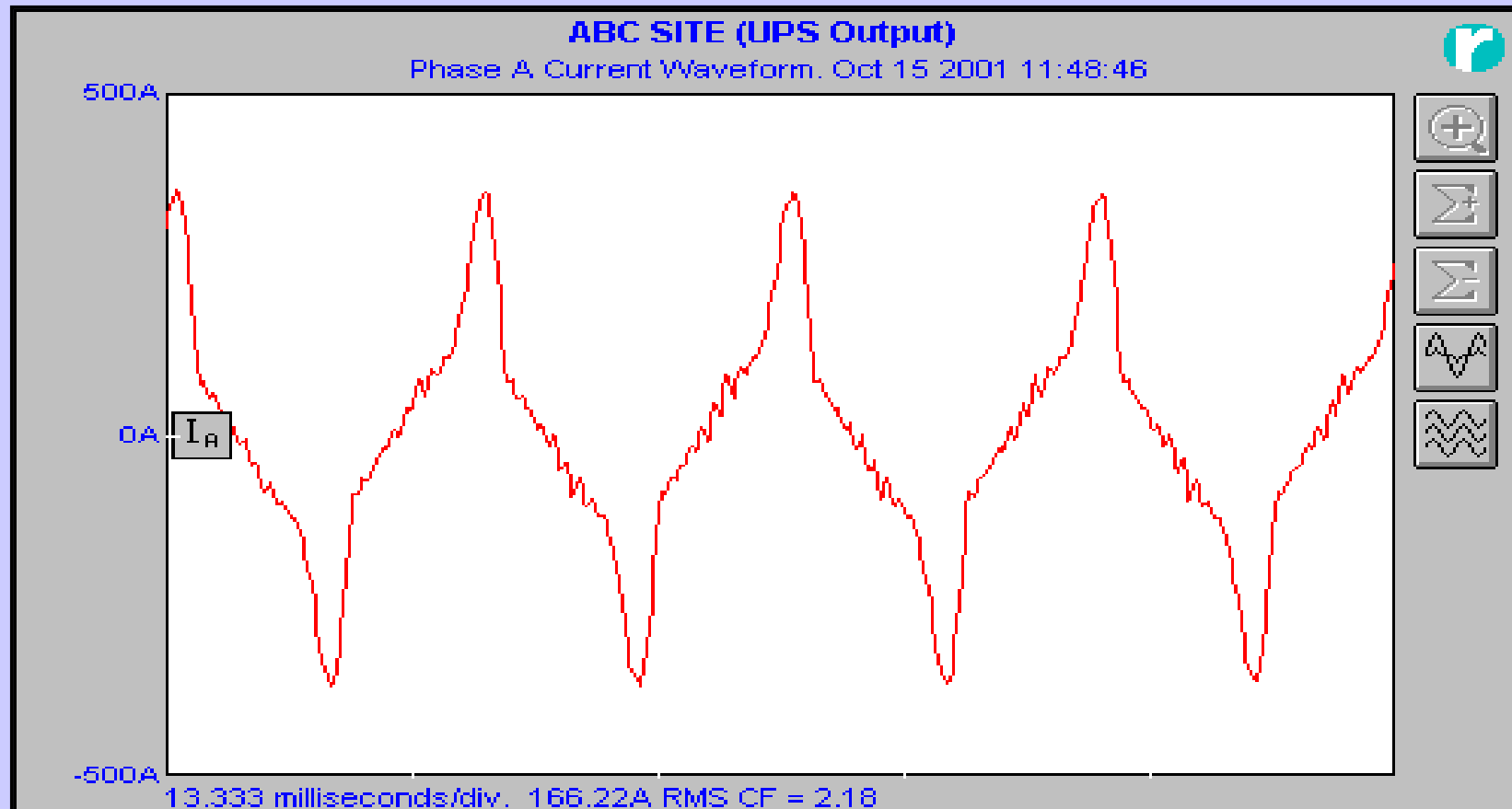


# UPS Output Current Waveform with Resistive Load





# UPS Output Current Waveform with Non-Linear Load



## **Conclusions**

- ◆ **On-Line Monitoring Equipment are Readily Available for Power Quality Measurements**
- ◆ **Conduct Power Quality Study to Determine any Existing System Abnormalities and when Installing new Equipment**
- ◆ **Voltage Sag is Considered the Most Costly Voltage Disturbance Problem**

**THANK YOU**

**ANY QUESTIONS, PLEASE !**

**Robert Hanna**