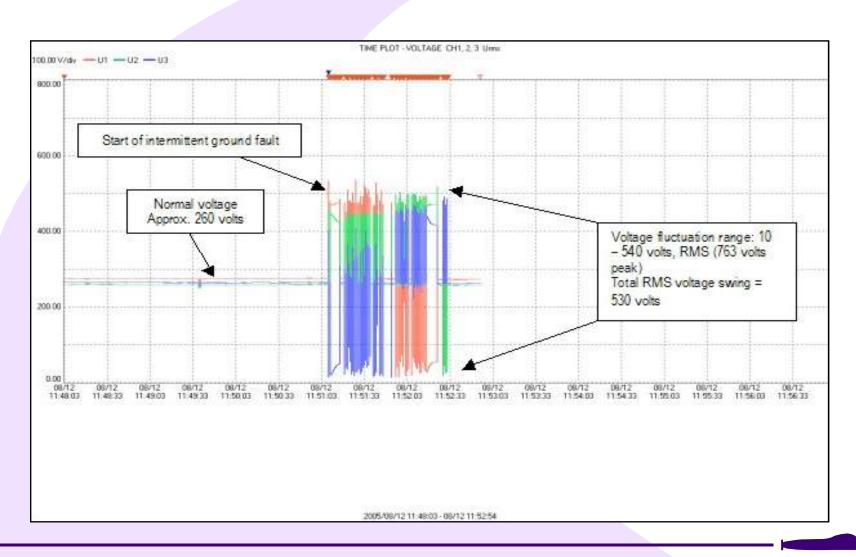


#### PQ Solution

- Leverage emerging technology, use passive voltage stabilizer, without active components
- Phaseback, electromagnetic voltage stabilizer unit made by Applied Energy, LLC
  - Trial unit attached to 750-KVA, 450-volt, Delta wound shore tie transformer
  - Severe ground faults manually induced at ship's main electrical switchboard while on shore power
    - Using inductive shorting lead with positive temperature coefficient 51-ohms and 25 ohms cold resistance impedance
- Initial tests 8/2005 to establish non-protected and protected voltage stability of ship power



### 51-ohm Induced Ground Fault Without Voltage Stabilization



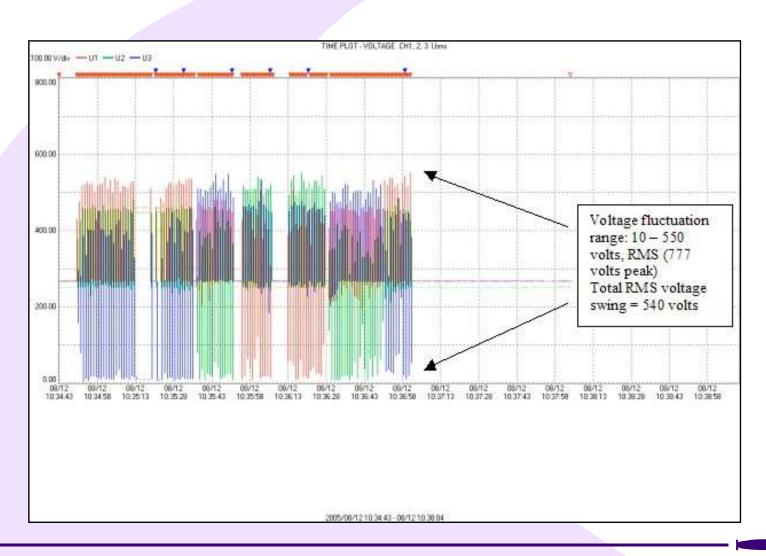


#### 51-ohm Induced Ground Fault With Voltage Stabilization



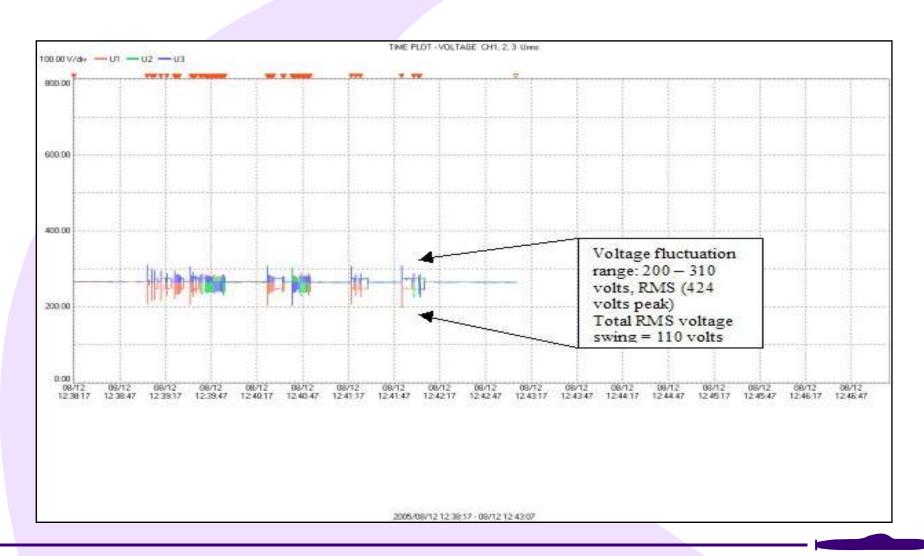


### 25-ohm Induced Ground Fault Without Voltage Stabilization





### 25-ohm Induced Ground Fault With Voltage Stabilization



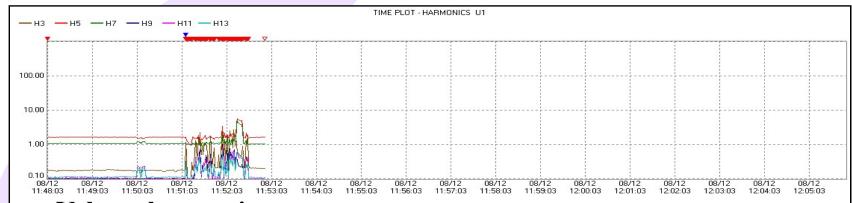


#### Ground Faults are a Harmonic Voltage Source

Another issue related to ground faults is that of harmonics generated by the ground fault. When a ground fault appears on a voltage system, there is an appreciable increase in voltage harmonics. These harmonics tend to circulate among the connected loads where they generate additional heat.



# Ground-Fault Harmonics Without Voltage Stabilization



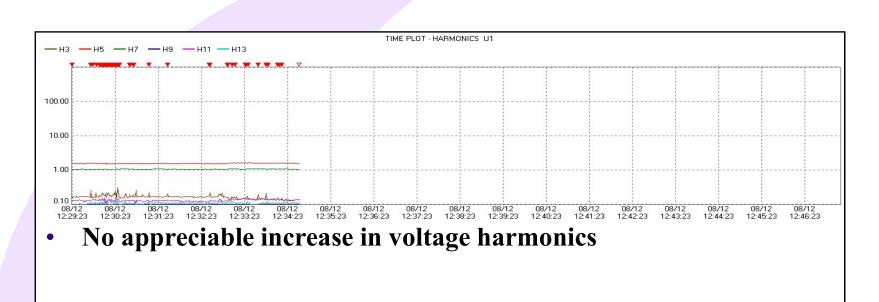
#### • Voltage harmonics:

- 3rd = 0.25%, increased to 1.2%
- 5th = 2.3%, increased to 7.6%
- 7th = 1.0%, increased to 7%

2005/08/12 11:48:03 - 08/12 11:52:54



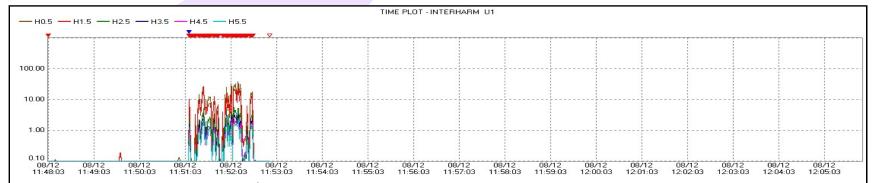
## Ground-Fault Harmonics With Voltage Stabilization



2005/08/12 12:29:23 - 08/12 12:34:39

# ELECTROMAGNETIC MISSION ASSURANCE CENTER

## Ground-Fault Inter-Harmonics Without Voltage Stabilization



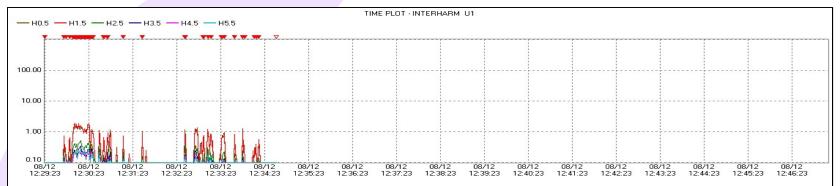
#### Voltage harmonics:

- 0.5th = <0.1%, increased to 50%
- 1.5th = <0.1%, increased to 40%
- 2.5th = <0.1%, increased to 8%
- 3.5th = <0.1%, increased to 3.5%
- 4.5th = <0.1%, increased to 3%
- 5.5th = <0.1%, increased to 2.5%

2005/08/12 11:48:03 - 08/12 11:52:54

## ELECTROMAGNETIC MISSION ASSURANCE CENTER

## Ground-Fault Inter-Harmonics With Voltage Stabilization



#### Voltage harmonics:

- 0.5th = <0.1%, no increase
- 1.5th = <0.1%, increased to 3%
- 2.5th = <0.1%, increased to 0.8%
- 3.5th = <0.1%, increased to 0.5%
- 4.5th = <0.1%, increased to 0.3%
- 5.5th = <0.1%, increased to 0.325%

2005/08/12 12:29:23 - 08/12 12:34:39