Similarly, current total harmonic distortion is calculated as:

$$I\ thd = \frac{\sqrt{I_2^2 + I_3^2 + I_4^2 + I_5^2 + \ldots.}}{I_1} \times 100\%$$

Voltage distortion then is a function of both the system impedance and the amount of harmonic current in the system. The higher the system impedance (ie. long cable runs, high impedance transformers, the use of diesel generators or other weak sources) the higher the voltage distortion.

In Figure 6-1, we see that voltage distortion is greatest at the loads themselves, since the harmonic currents are subjected to the full system impedance (cables, transformer and source) at that point. This is a characteristic most often misunderstood. It means that even if voltage distortion levels are low at the service entrance, they can be unacceptably high at the loads themselves. It also emphasizes the importance of keeping system impedances relatively low when servicing non-linear loads.

Voltage distortion can be minimized by removing the harmonic currents (I_h) and/or lowering the system impedance (Z_h) to the harmonics. (For further information on the relationship between voltage drop and voltage distortion and how to minimize them, we recommend two MIRUS technical papers titled (1) *'Taming the Rogue Wave – Techniques for Reducing Harmonic Distortion'* and (2) *'How the Harmonic Mitigating Transformer Outperforms the K-Rated Transformer'*).

7. What ill effects do harmonics created by VFD's have on themselves and the motor they supply?

Typical voltage distortion in the form of a severely flat-topped voltage waveform will translate to a lower DC bus voltage within the VFD. A lower DC voltage will prevent the inverter section of the VFD from generating a full rms AC voltage to the motor. When running near full load, a motor starved for voltage will draw more than its rated current, overheat and be prone to failure.

In addition, commutation notching/overvoltages caused by the operation of thyristor bridge rectifiers (or SCR's) in DC Drives or similar loads, have been known to cause AC Drive shutdowns and failures. Figure 7.1 shows voltage distortion on an off-shore oil platform with DC Drives. The severe voltage notching and overvoltages caused AC Drive failures until they were protected by LINEATOR™ AUHF's.

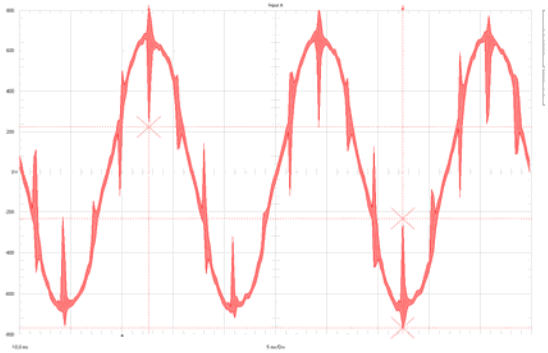

Figure 7.1: Voltage notches/overvoltages caused by the operation of DC Drives on an off-shore oil platform