

Harmonic Reduction Techniques

Presented at the

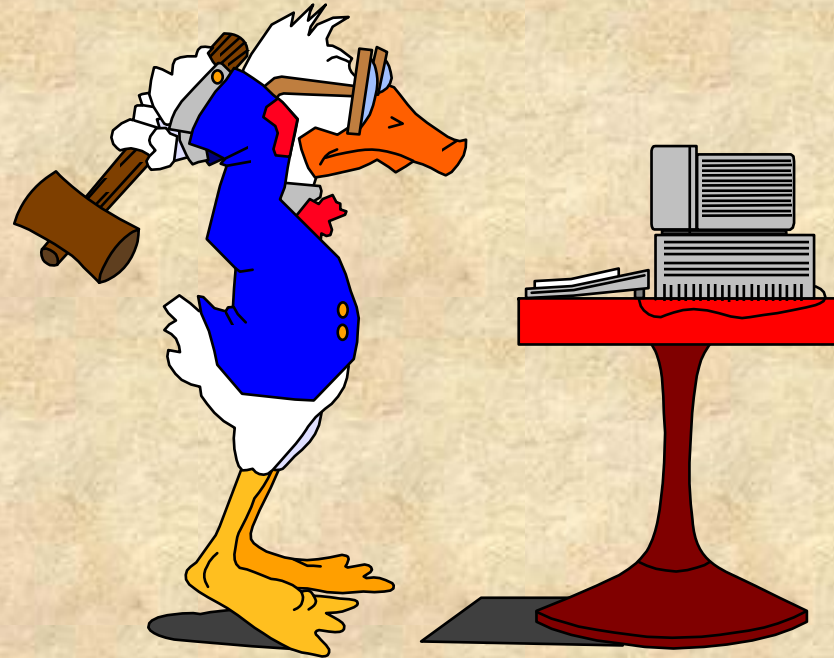
IEEE Nashville Chapter

Presented by

Reza Tajali, P.E.

Tel: 615-844-8663 Email: reza.tajali@schneider-electric.com

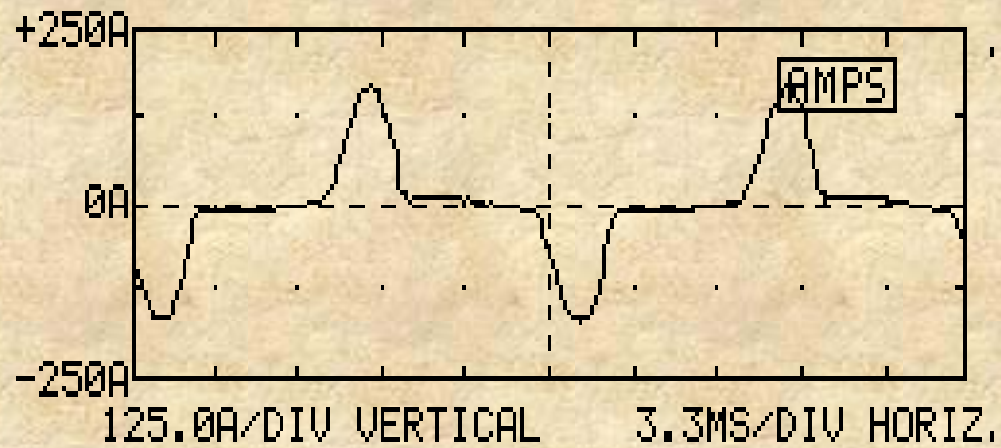
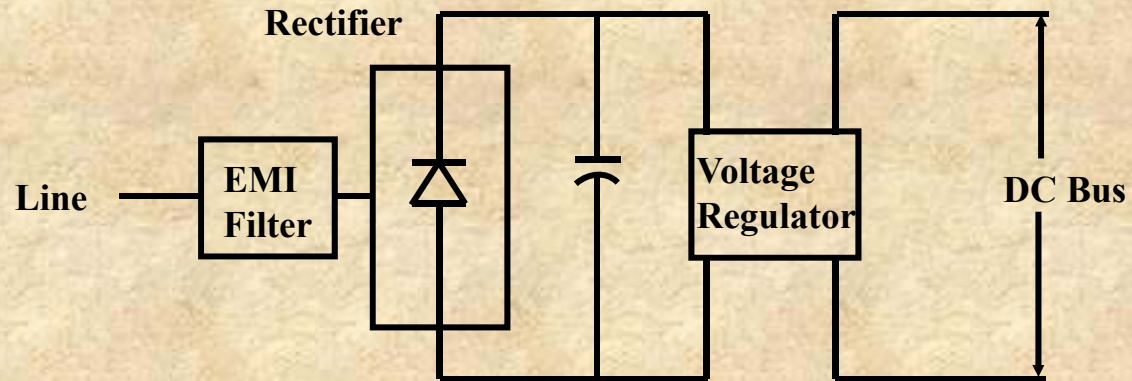
All Your Problems Are Nails
Because We Have a Hammer



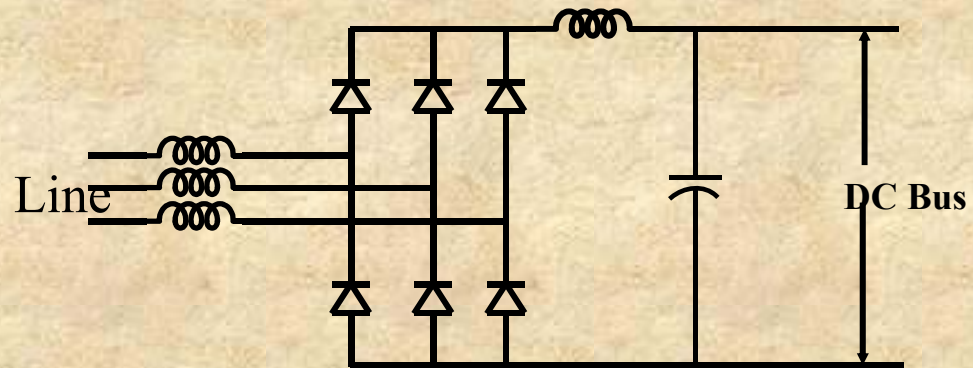
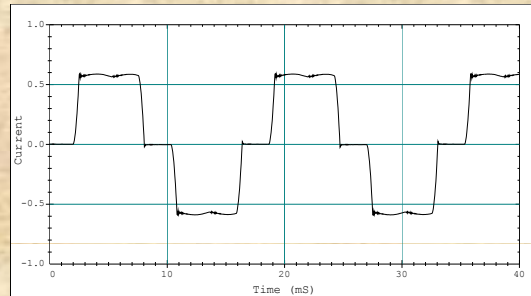
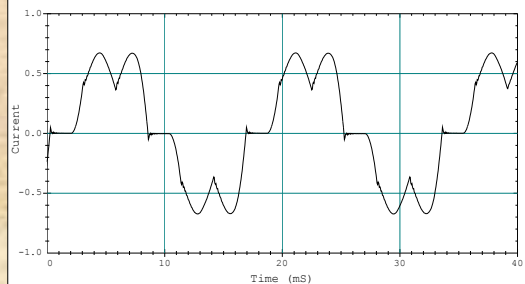
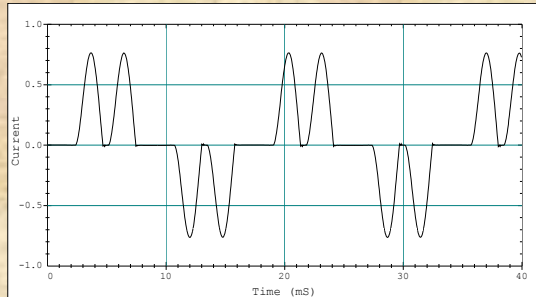
Harmonics, Key Concepts

- I. What is the problem with harmonics?
- II. How do they come about?
- III. How do they add up?
- IV. The concept of power quality as voltage quality
- V. How to reduce them?

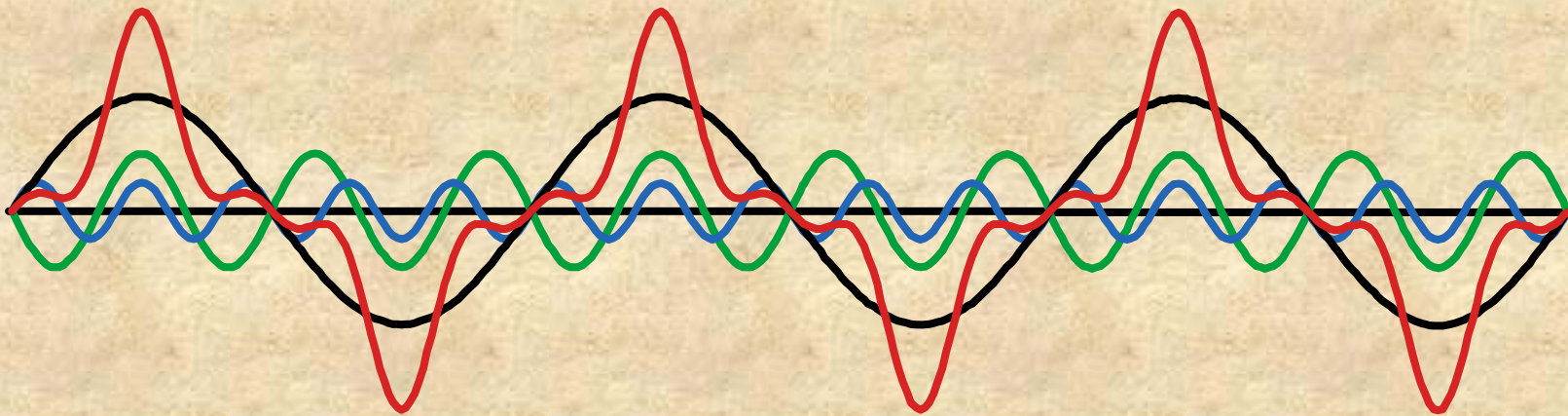
II-The Single Phase Power Supply



II. The Three Phase Power Supply

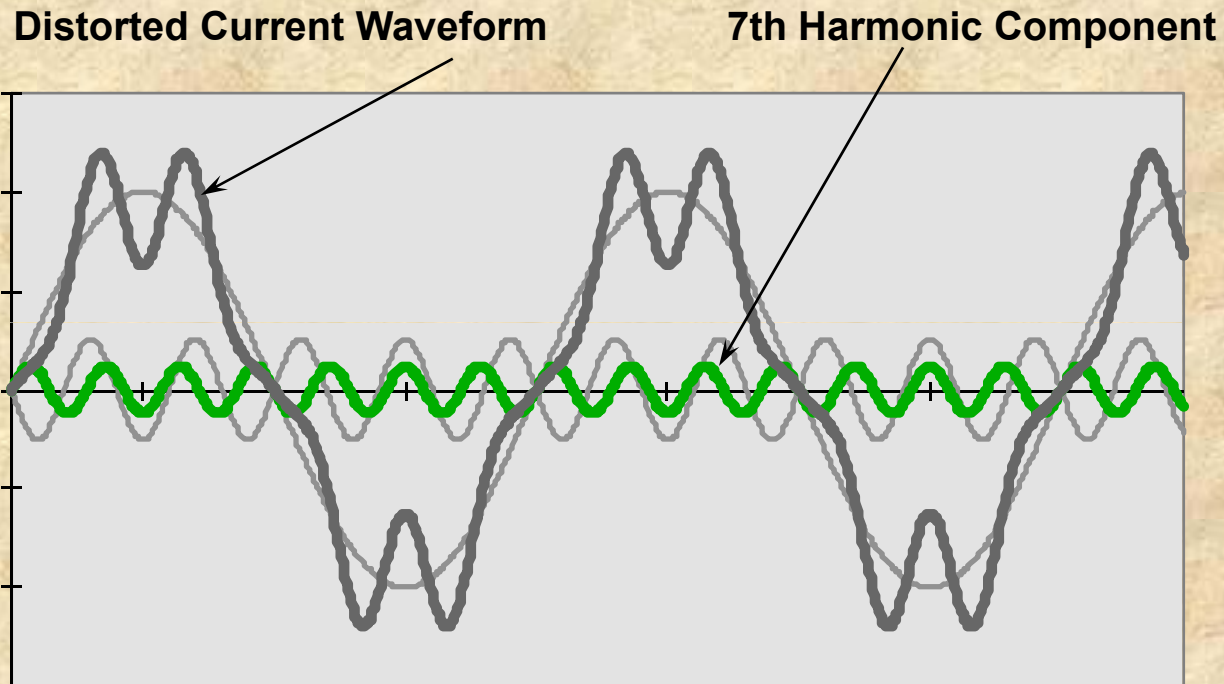


III. How do Harmonics Add Up?



Fundamental (1st harmonic) - 85%
3rd harmonic - 45%
5th harmonic - 27%

III. How do Harmonics Add Up?



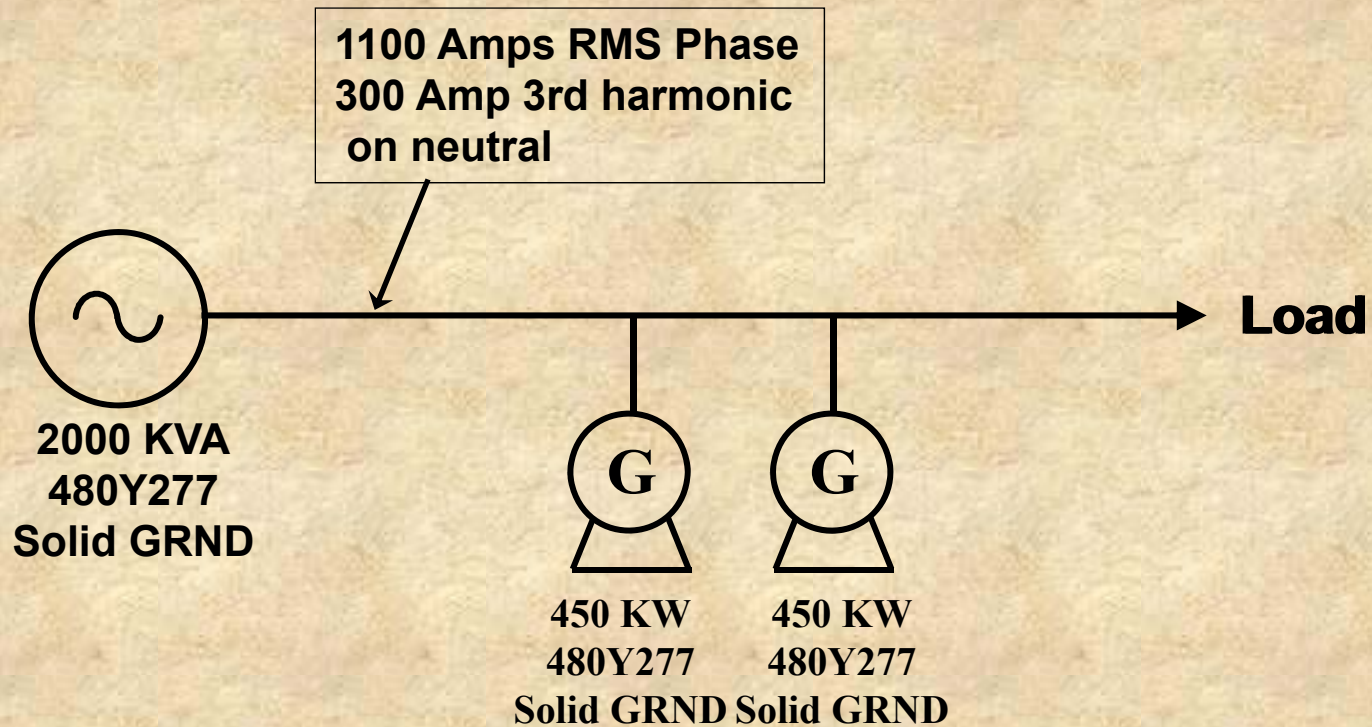
Instantaneous Relationship

$$i = i_1 + i_2 + i_3 + \dots$$

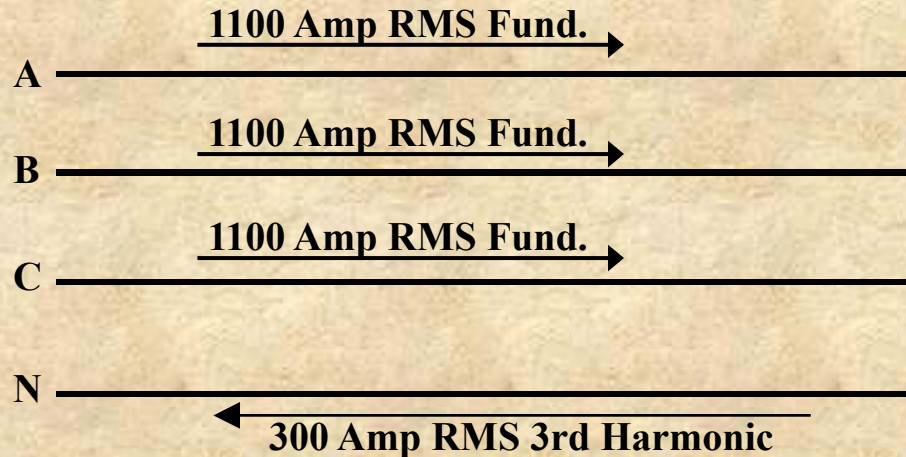
RMS Relationship

$$I^2 = I_1^2 + I_2^2 + I_3^2 + \dots$$

Case History #1 Manufacturing Plant Generator Cross Talk Harmonics



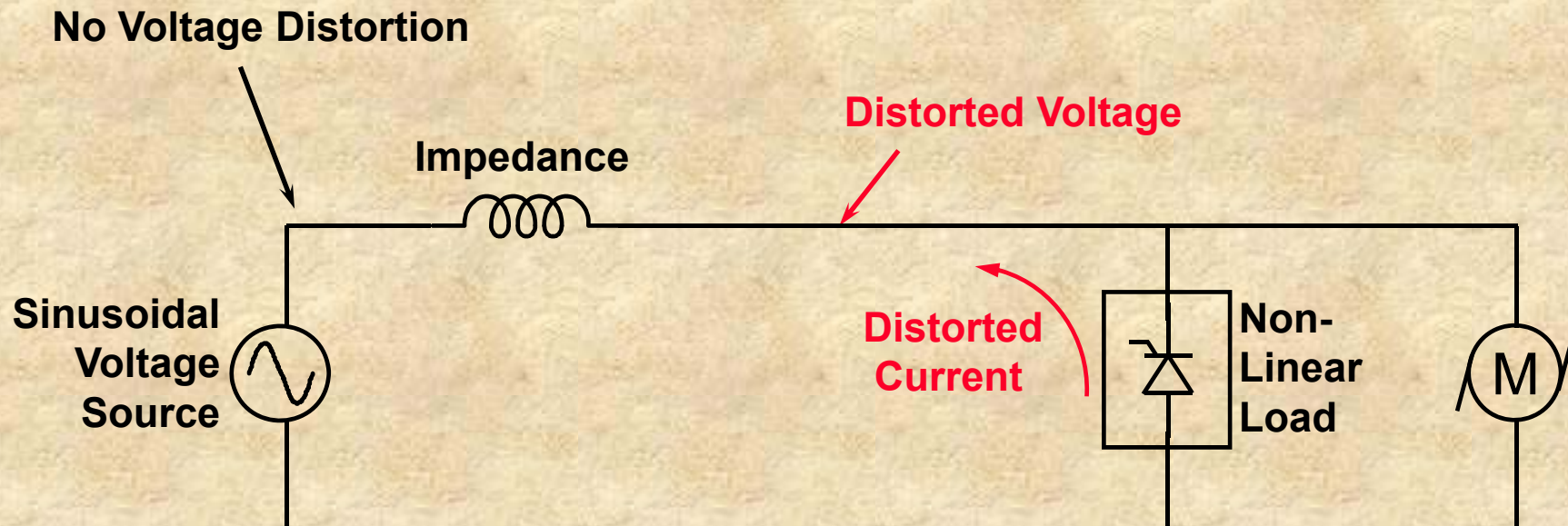
How Bad is the Third Harmonic?



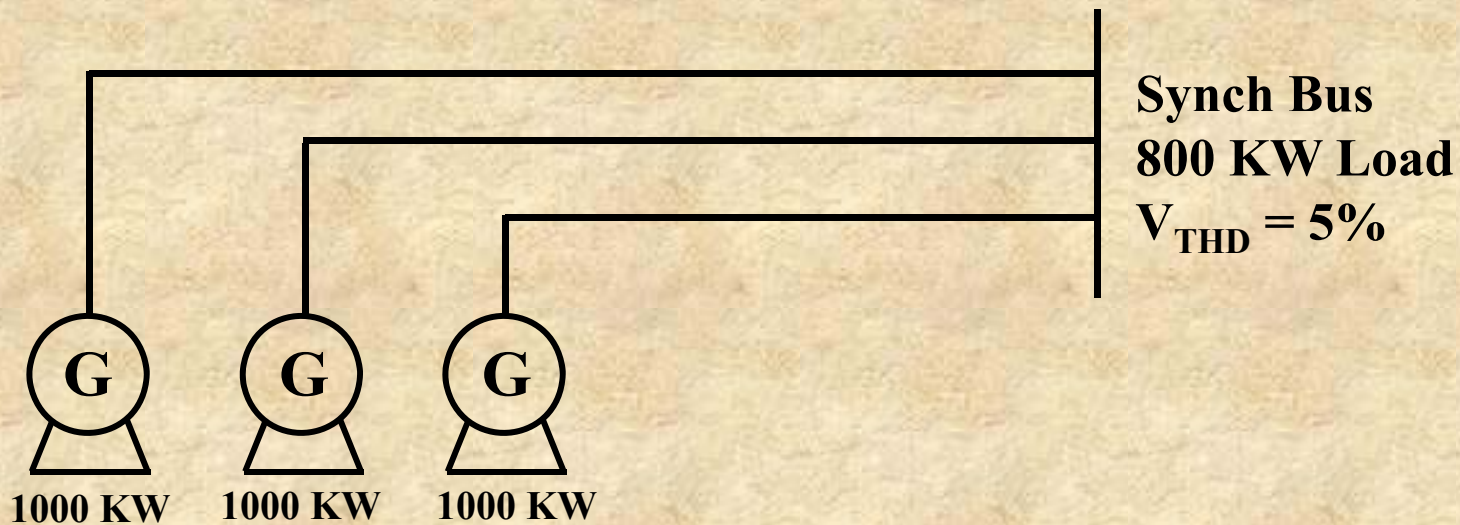
- **Third Harmonic = 9% of Fundamental**
- **Total $I^2 = (1100)^2 + (100)^2$**
- **$I = 1104$ Amps**

9% Third Harmonic Adds only 0.4% to Total RMS

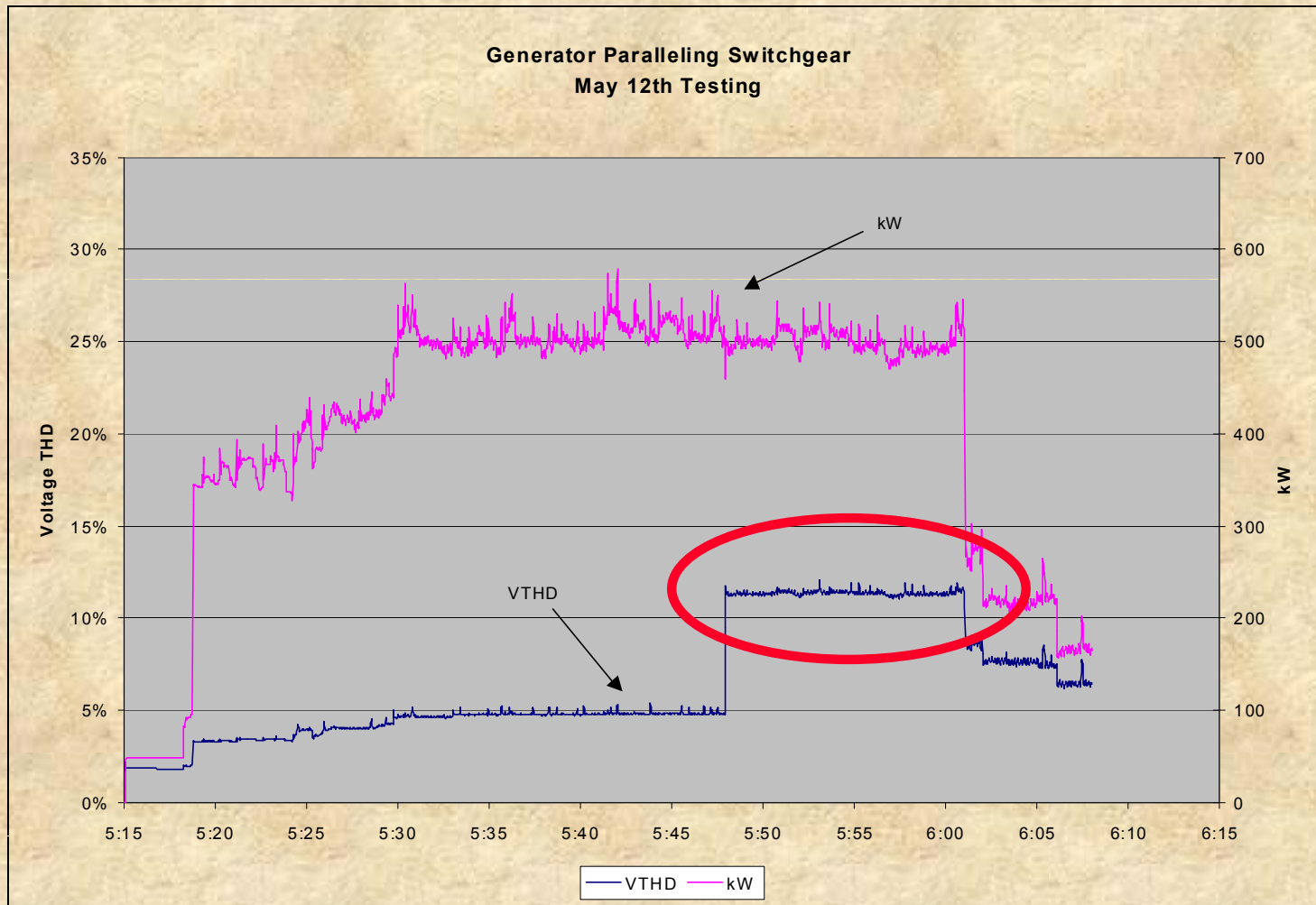
IV. Power Quality is Voltage Quality



Case History #2 Hospital's Emergency Generators



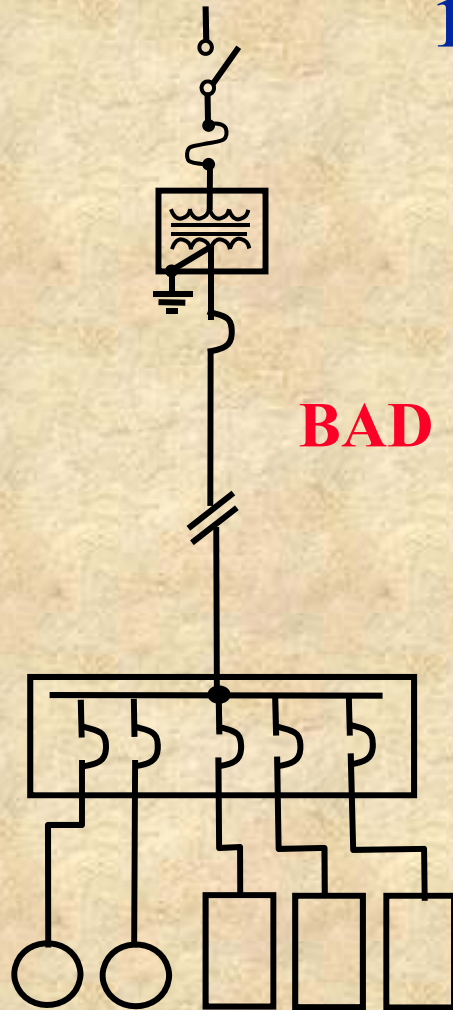
Hospital's Generators



V-Methods of Reducing Voltage Distortion

- 1- Isolate Harmonic Loads**
- 2. Reduce Generated harmonics**
 - Chokes, inductors, Isolation Transformer
 - 12 or 18 Pulse Drives
- 3- Reduce system impedance (Stiffen the source)**
- 4- Remove or reduce PF correction capacitors if resonance is present**
- 5- Use transformers to cancel harmonics**
- 6- Install capacitor-based harmonic filters if power factor is low**
- 7- Install an active filter**

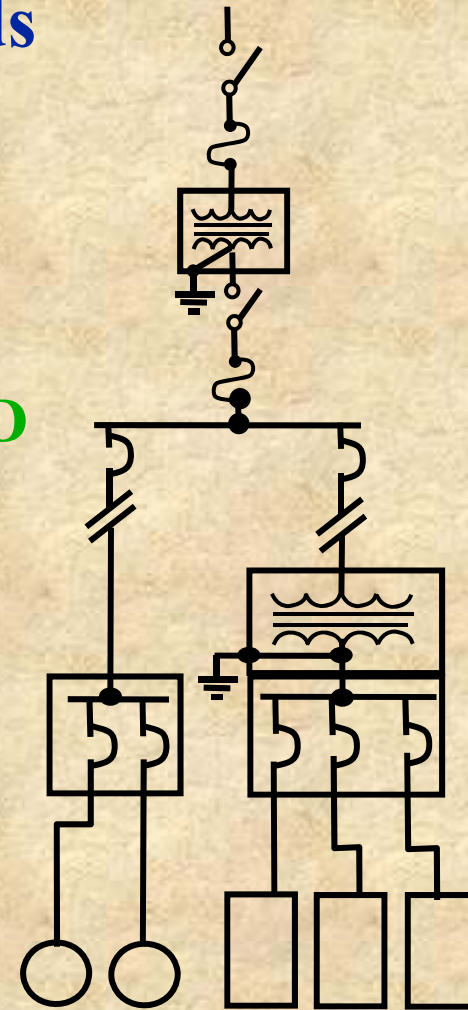
1. Segregate Loads IEEE-1100



BAD

Other Loads

Sensitive Loads



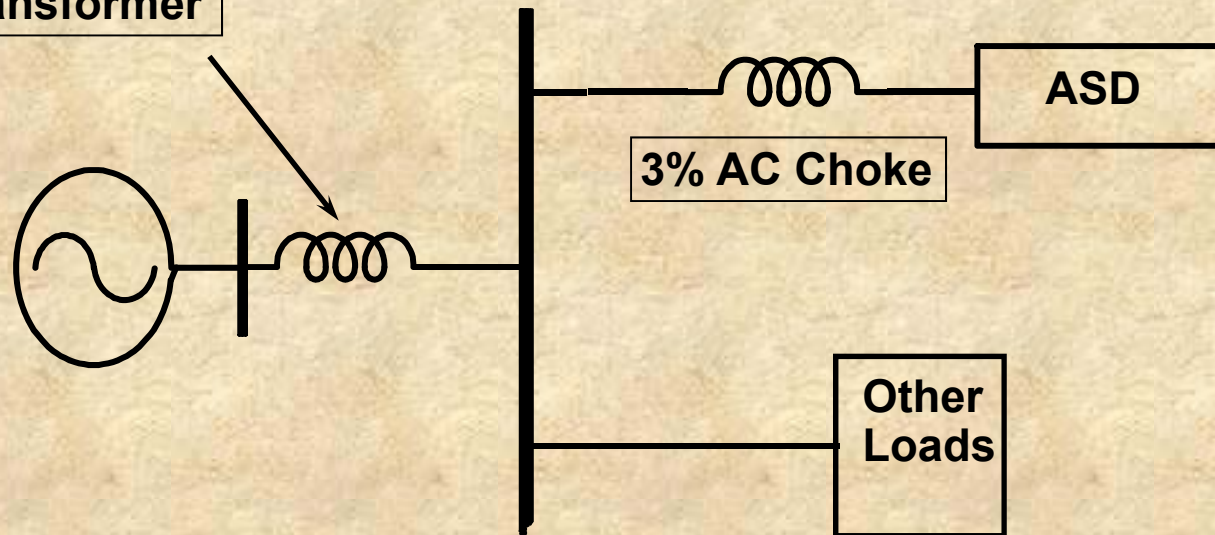
GOOD

Other Loads

Sensitive Loads

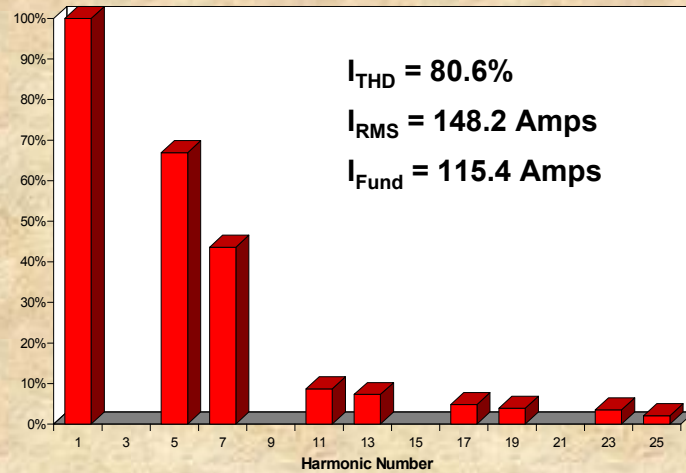
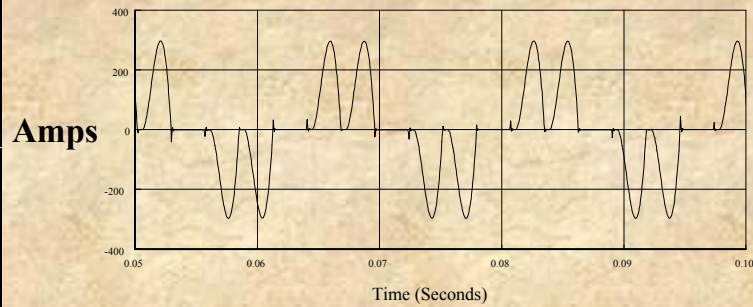
2 - Inductors Reduce the Generated Harmonics

1500 kVA Transformer

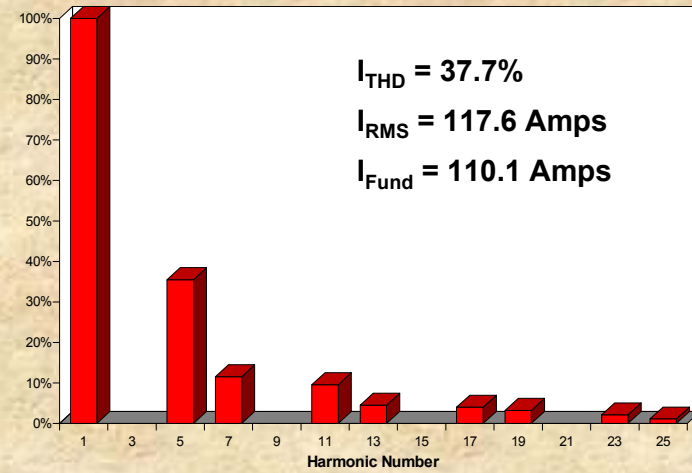
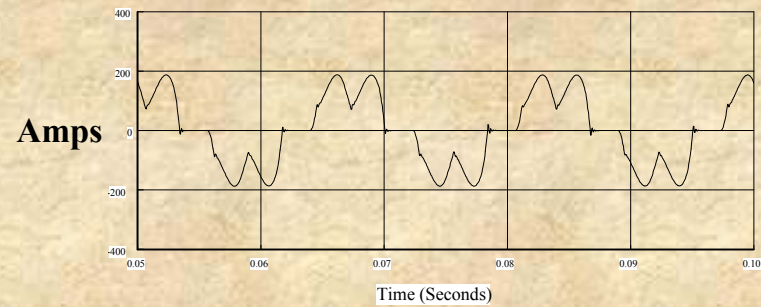


Why Inductance?

TYPE 1 Waveform
100 HP PWM ASD - No Choke



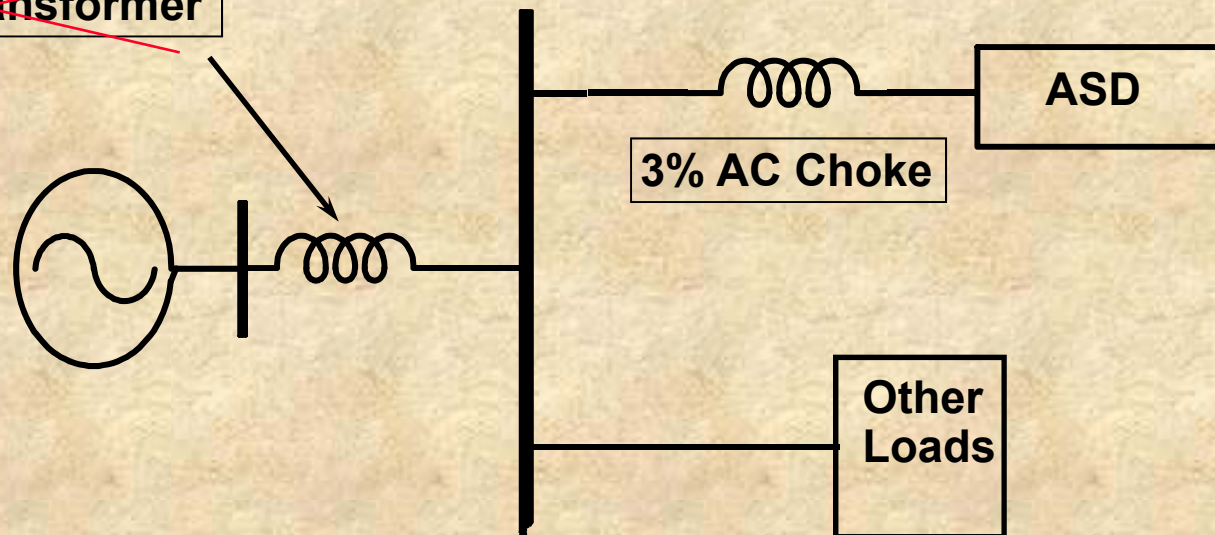
TYPE 2 Waveform
100 HP PWM ASD - 3% Choke



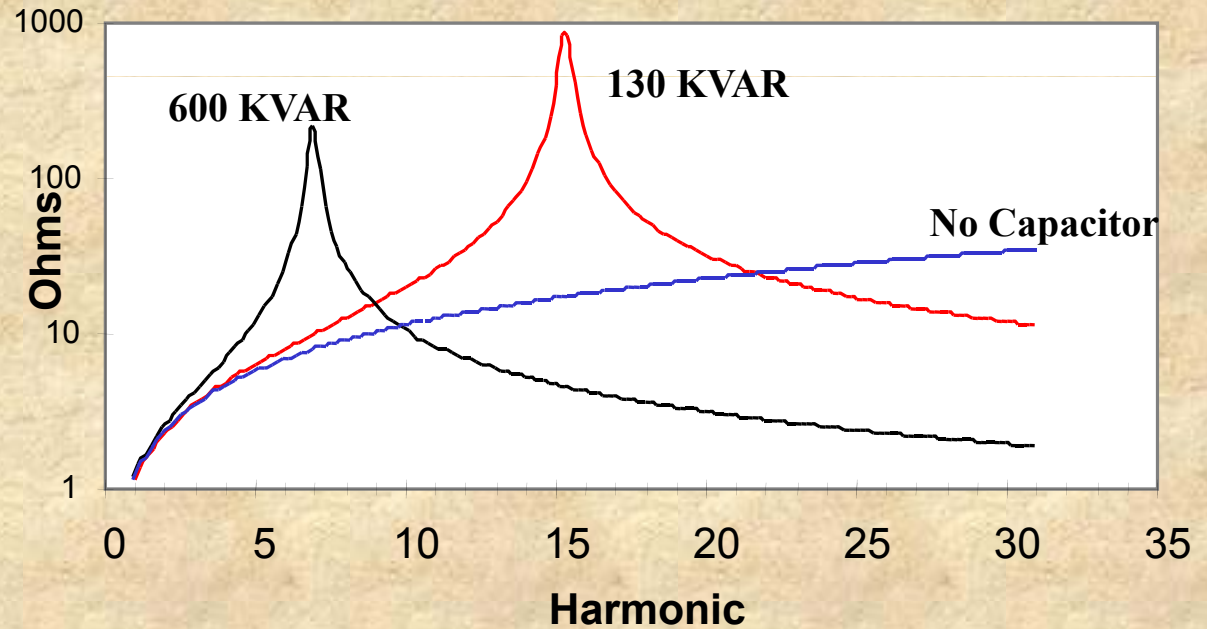
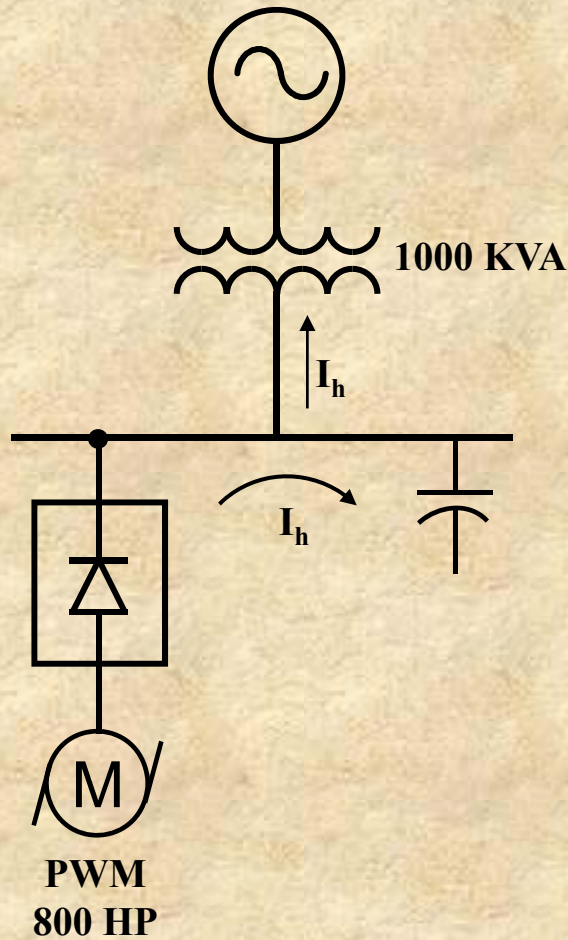
3 - Reduce System Source Impedance

2500 kVA Transformer

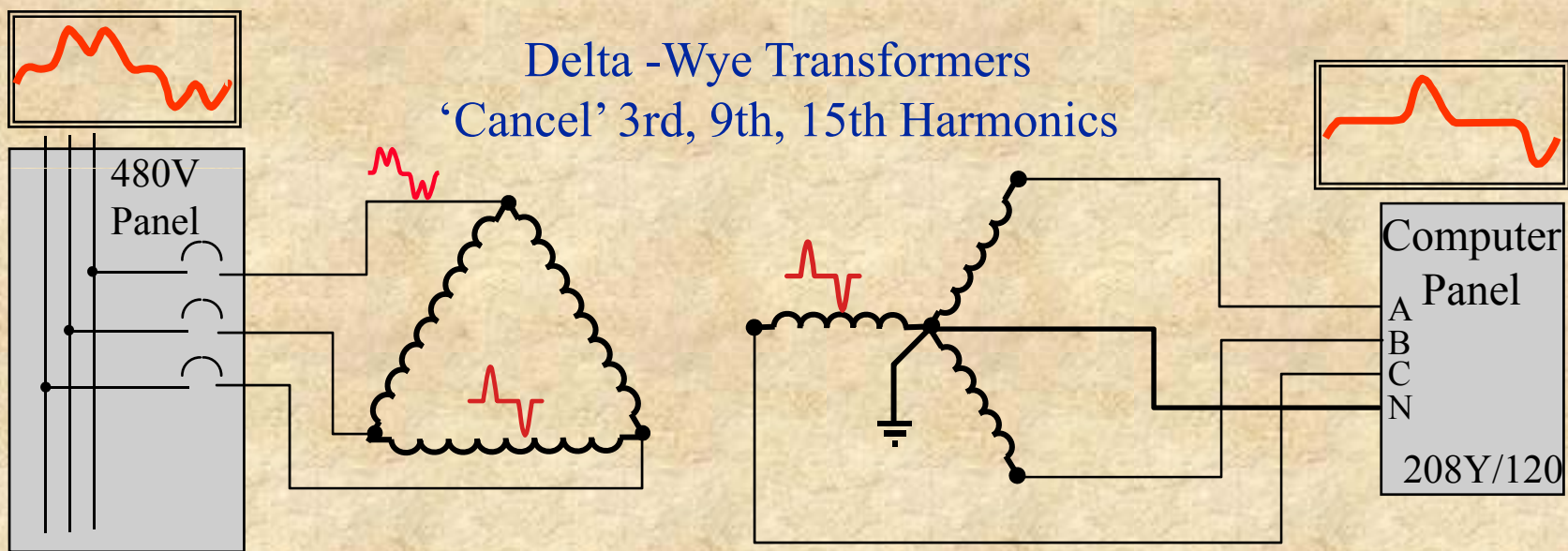
~~1500 kVA Transformer~~



4 – Remove or Reduce Capacitors When Resonance is Present



5 – Use Transformers to Cancel Harmonics



**30KVA 208 - 208Y/120
Transformer**

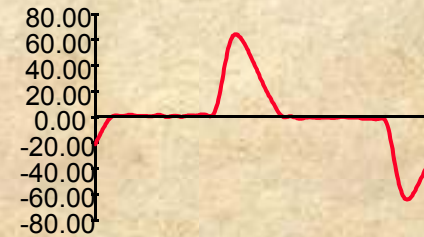
Primary



Harmonic	Angle	Amperes
1	-66	20.70
3	-113	0.19
5	-144	7.66
7	-61	3.56
9	24	0.17
11	-64	1.66
13	24	0.93
15	111	0.12

RMS Current 22.45
THD 41.92%
K-Factor 6.12
Real Power 3.332kW
Apparent Power 8.466kVA
Power Factor 0.39

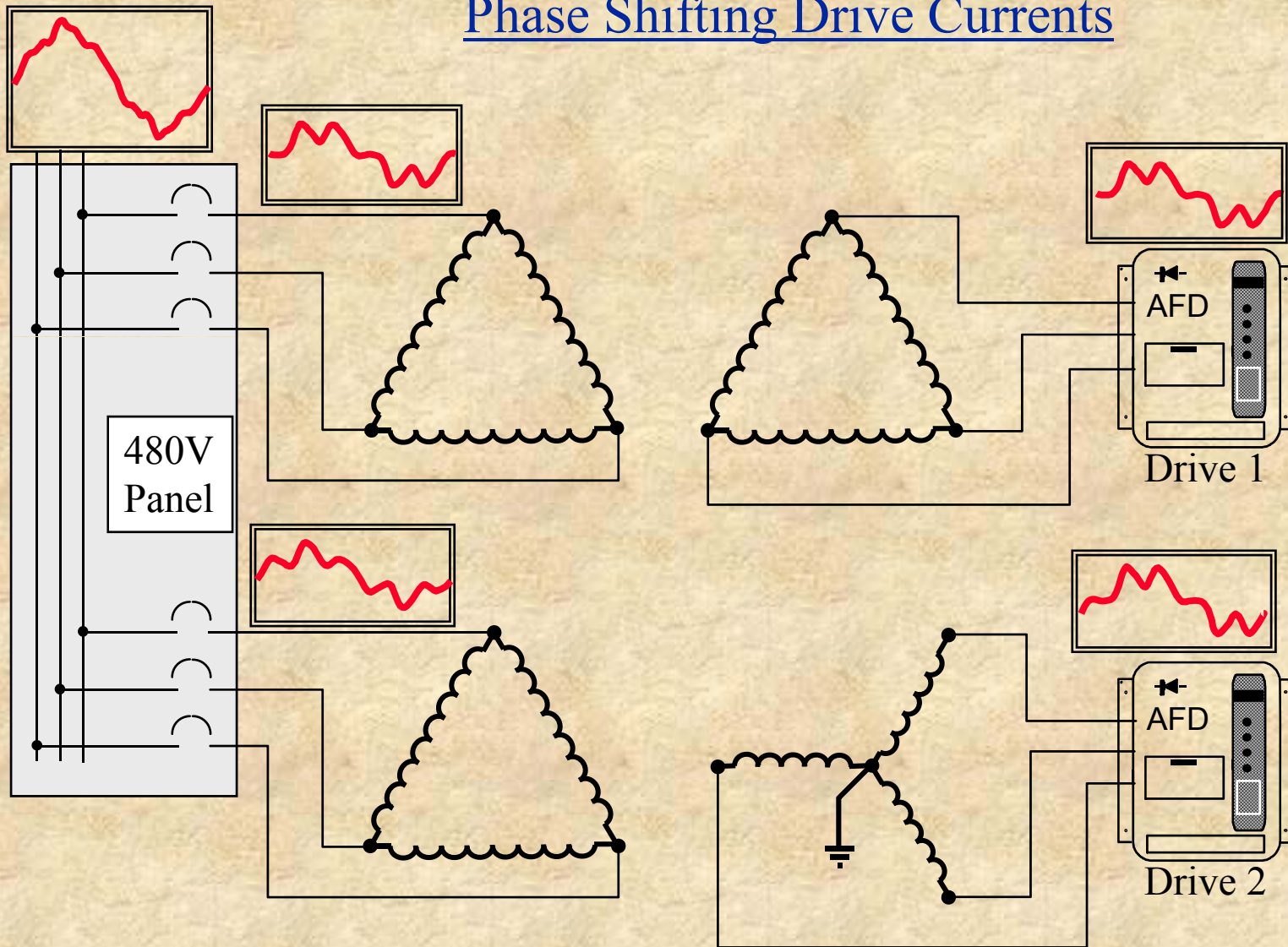
Secondary



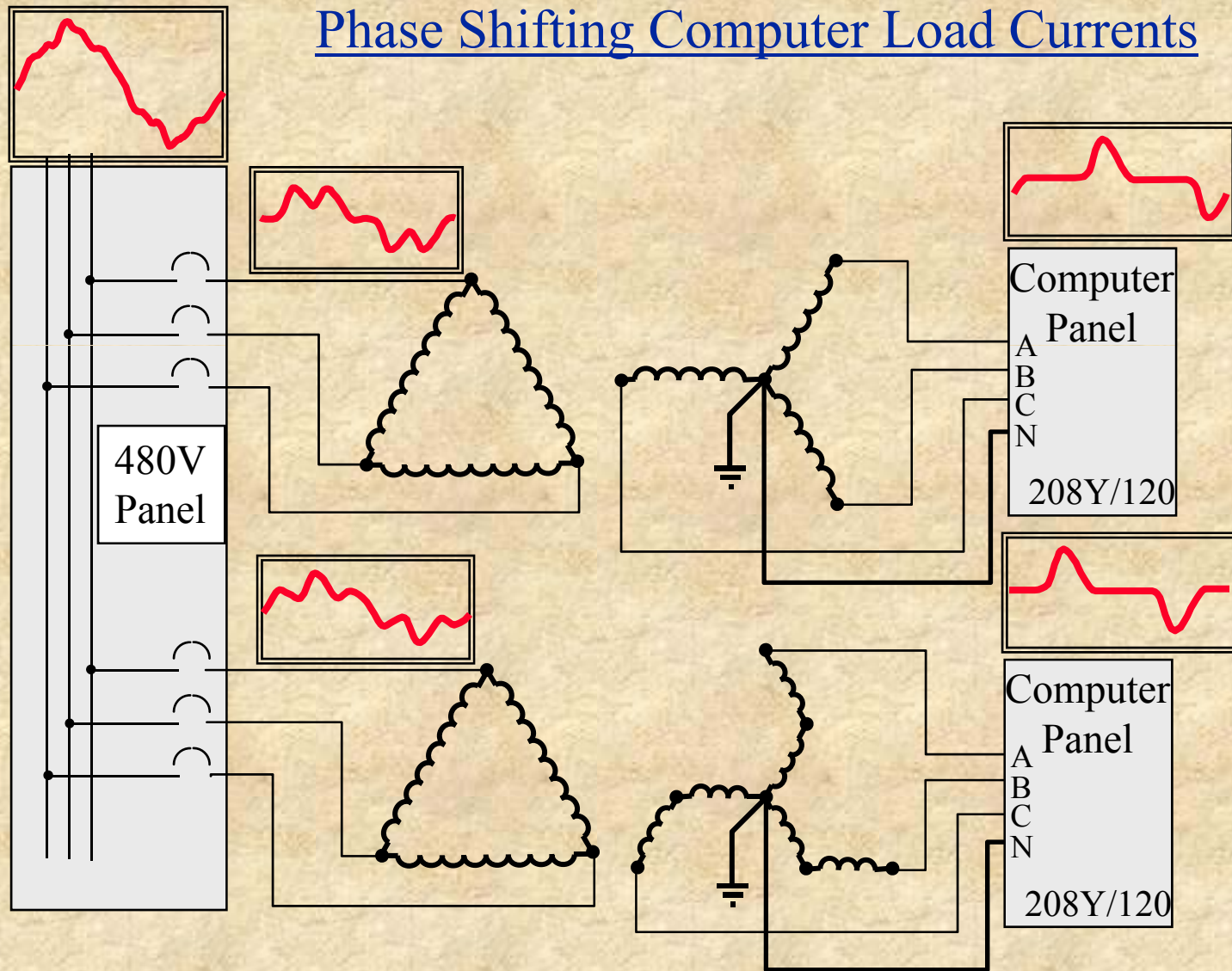
Harmonic	Angle	Amperes
1	-64	18.90
3	-15	14.31
5	41	7.86
7	121	3.48
9	-137	2.38
11	-53	1.64
13	34	0.77
15	154	0.60

RMS Current 25.40
THD 89.82%
K-Factor 8.35
Real Power 2.850kW
Apparent Power 9.153kVA
Power Factor 0.31
Neutral Current 43.56A (171%)

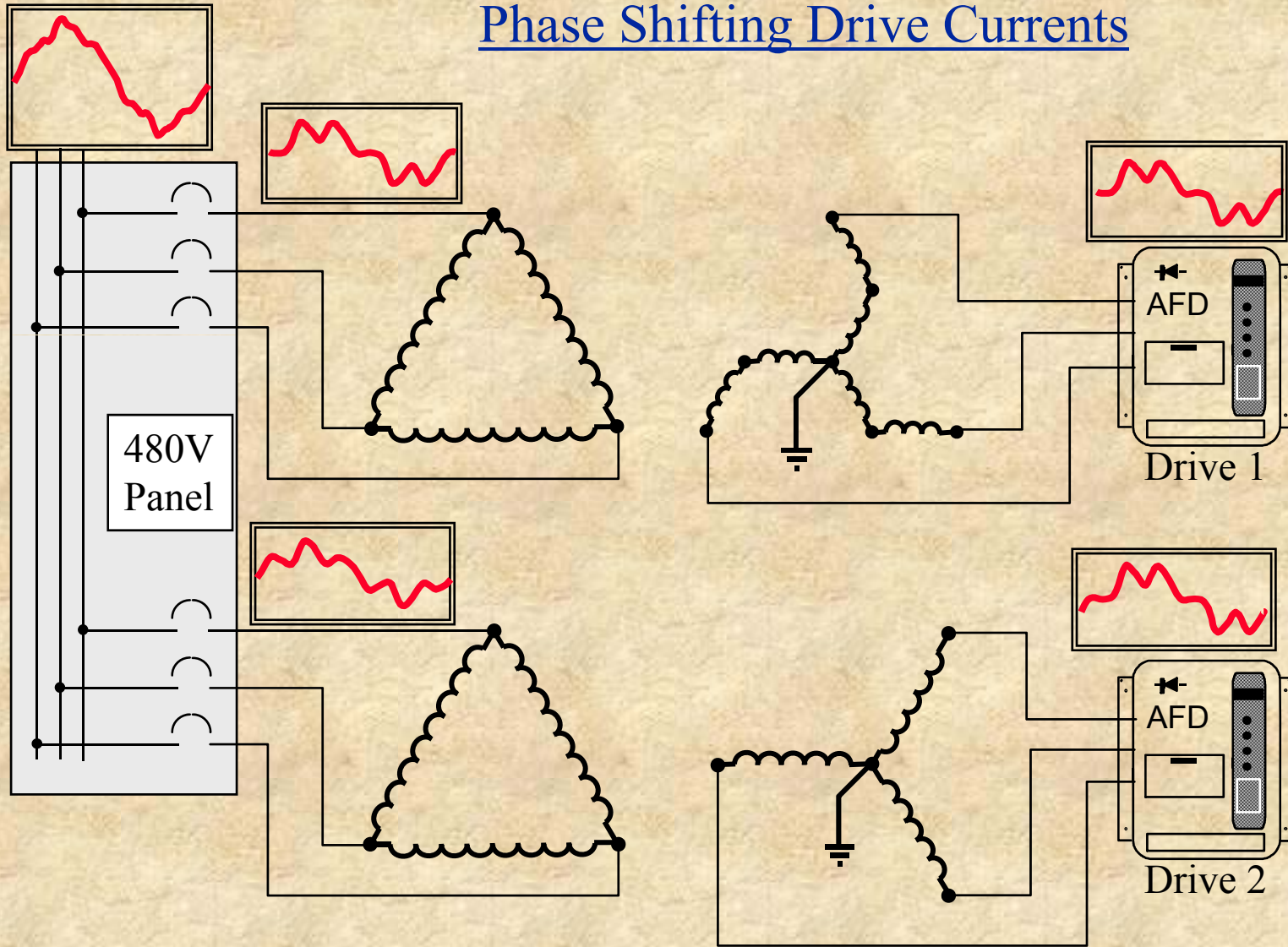
Phase Shifting Drive Currents



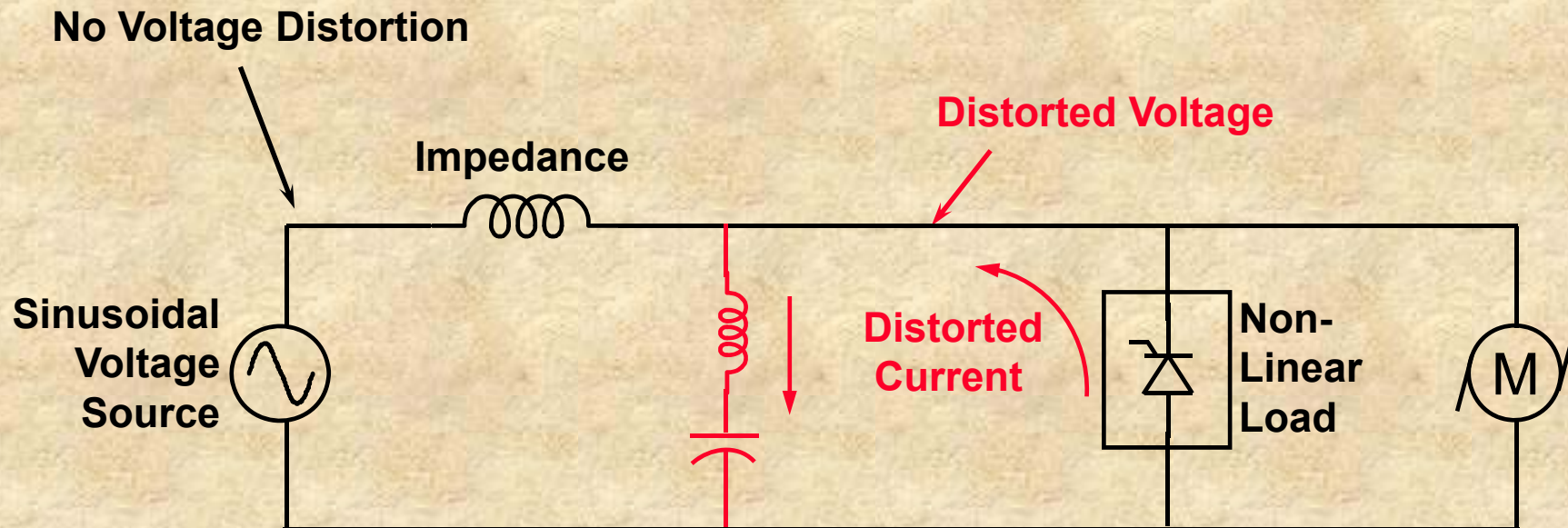
Phase Shifting Computer Load Currents



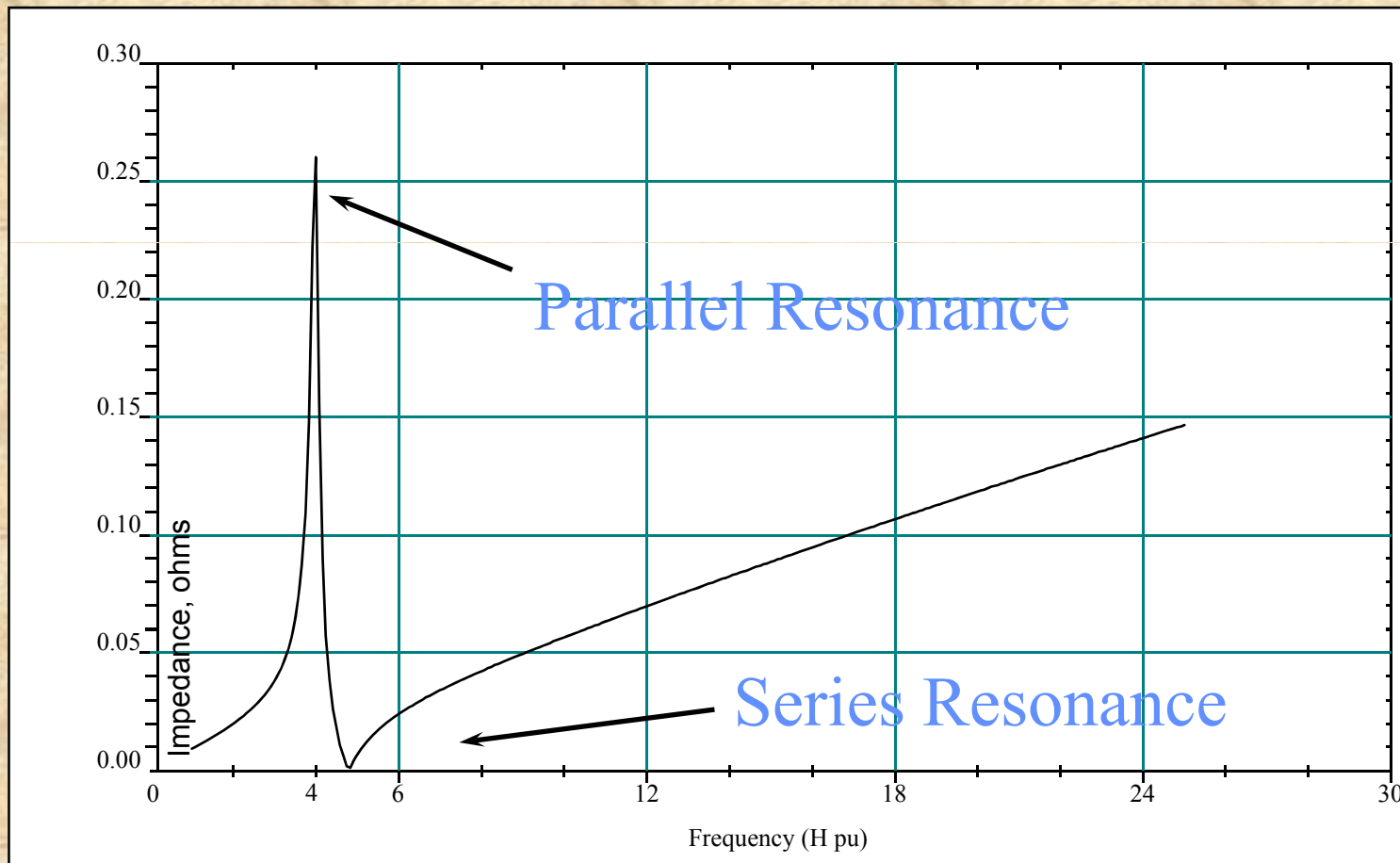
Phase Shifting Drive Currents



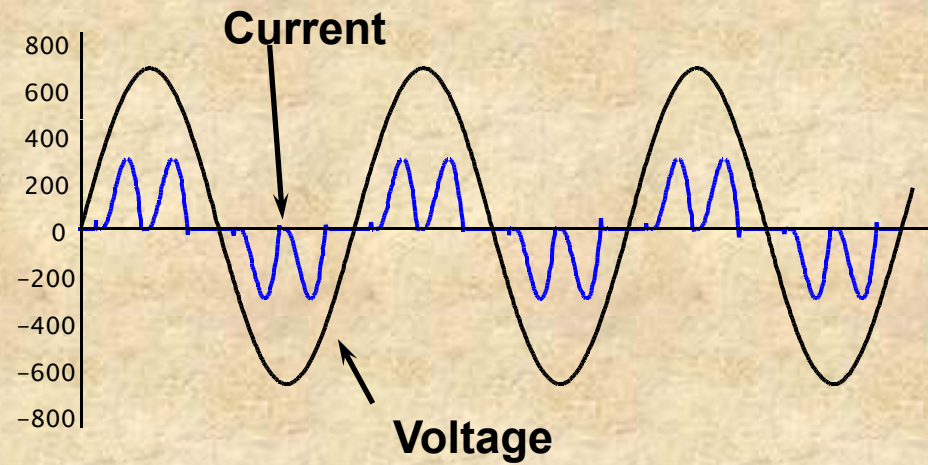
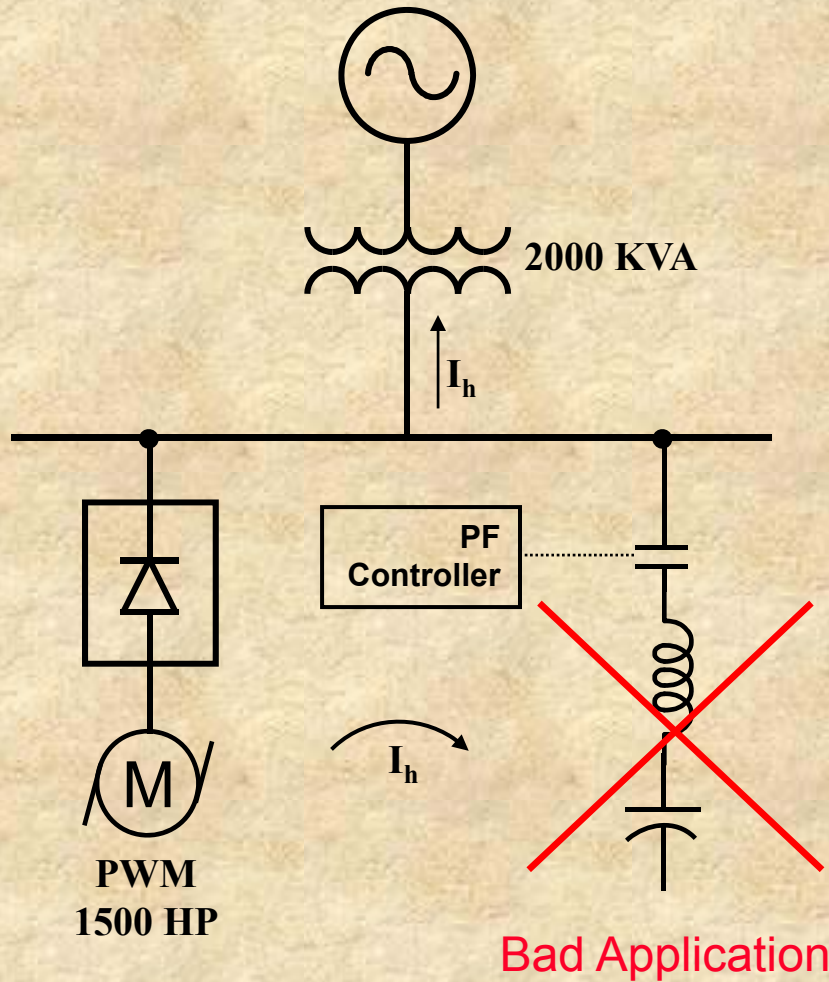
6. Install Capacitor-based Harmonic Filters



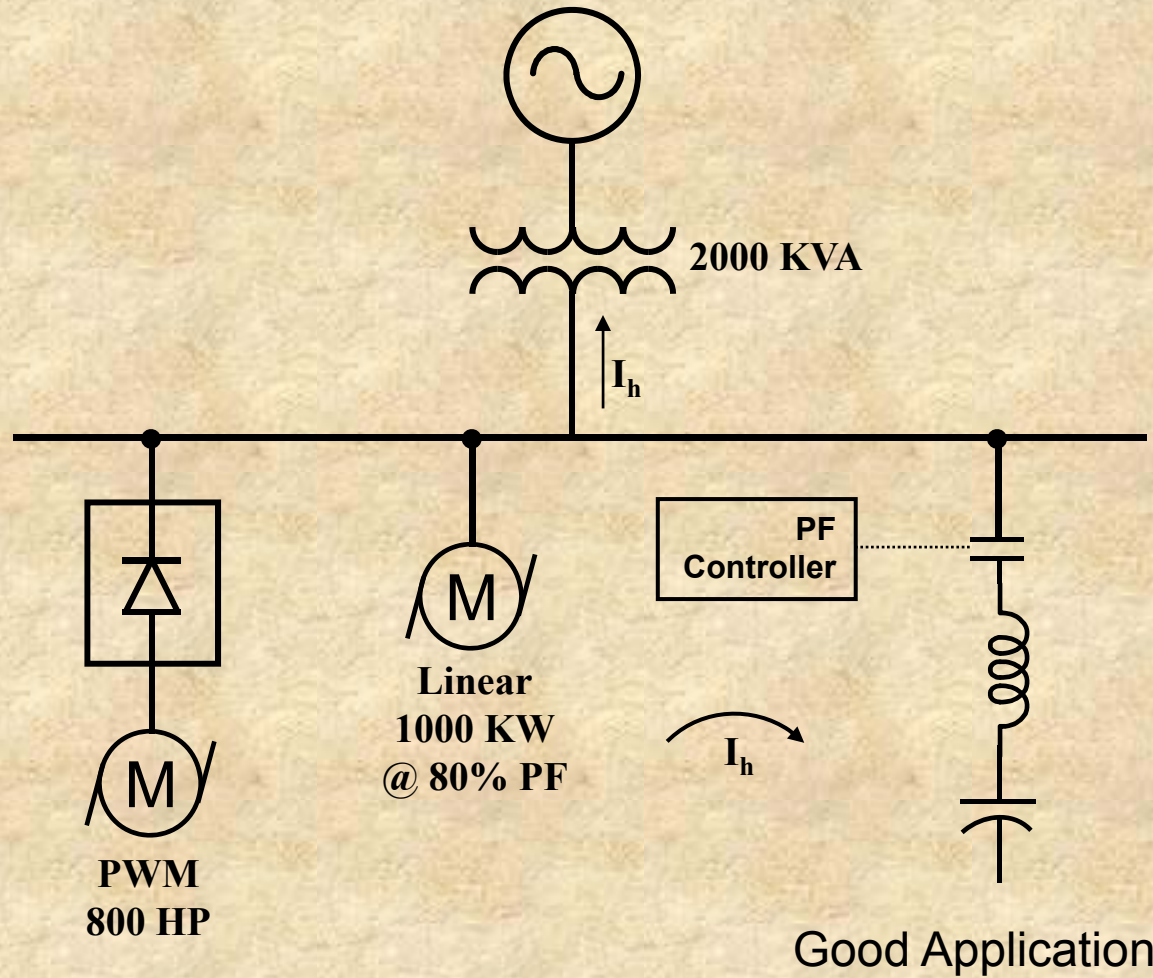
Harmonic Filter Utilizes Resonance



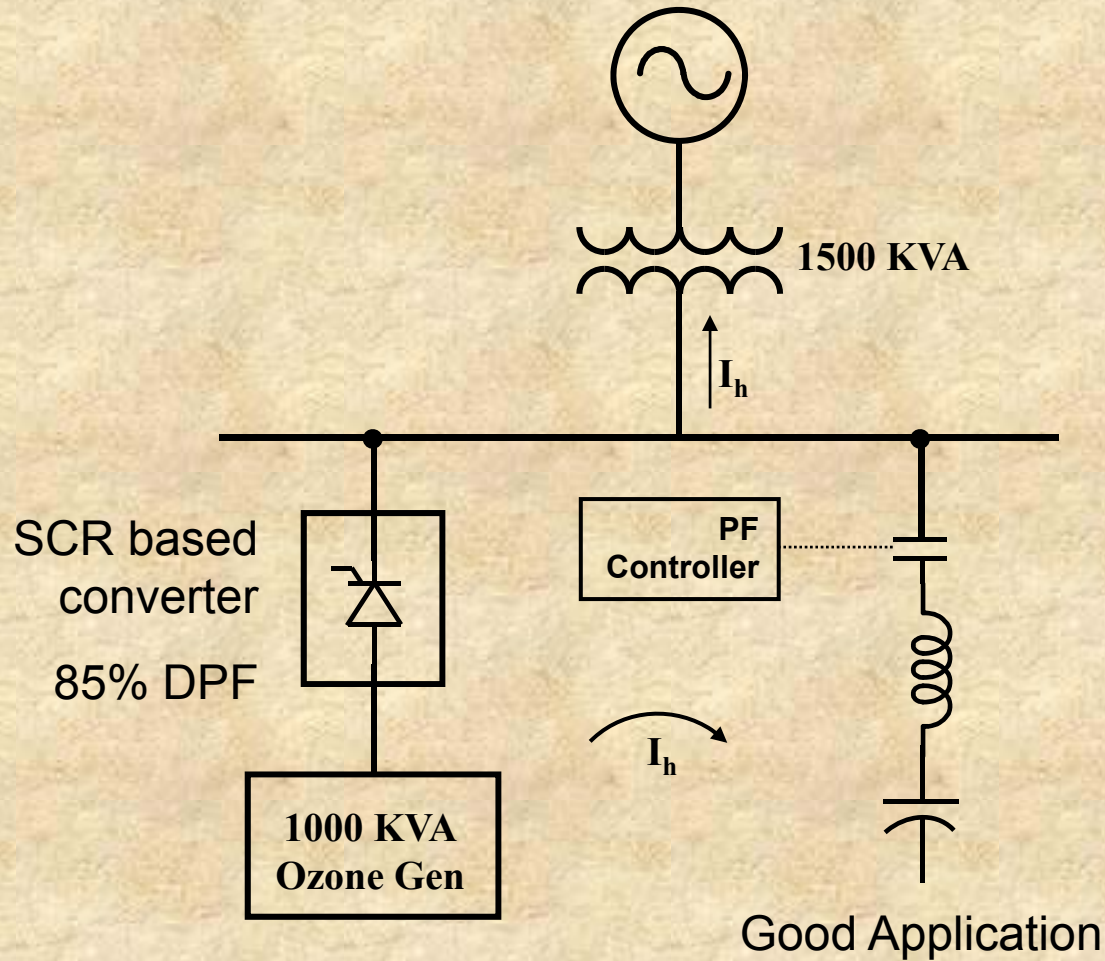
Filter Application



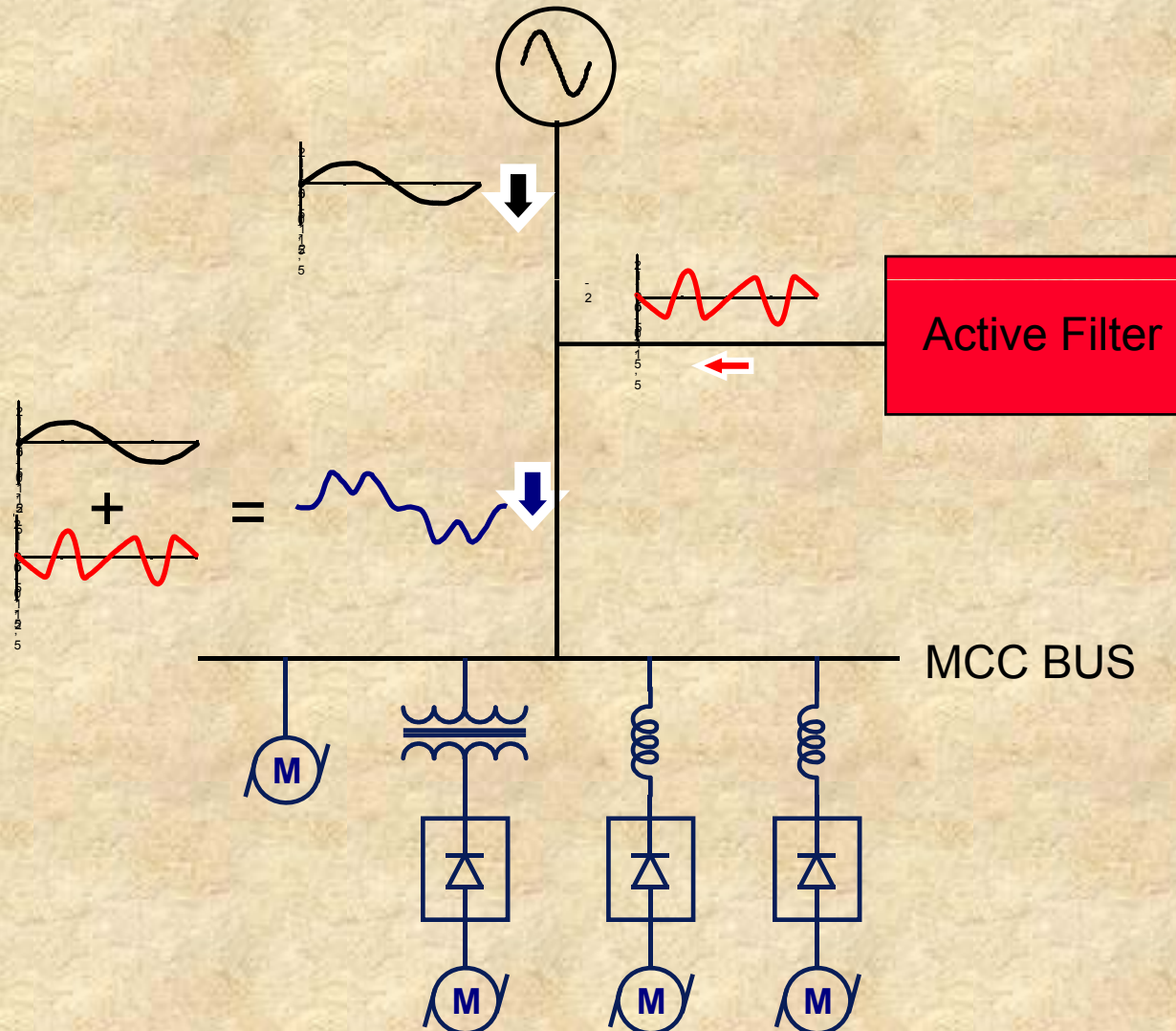
Filter Application



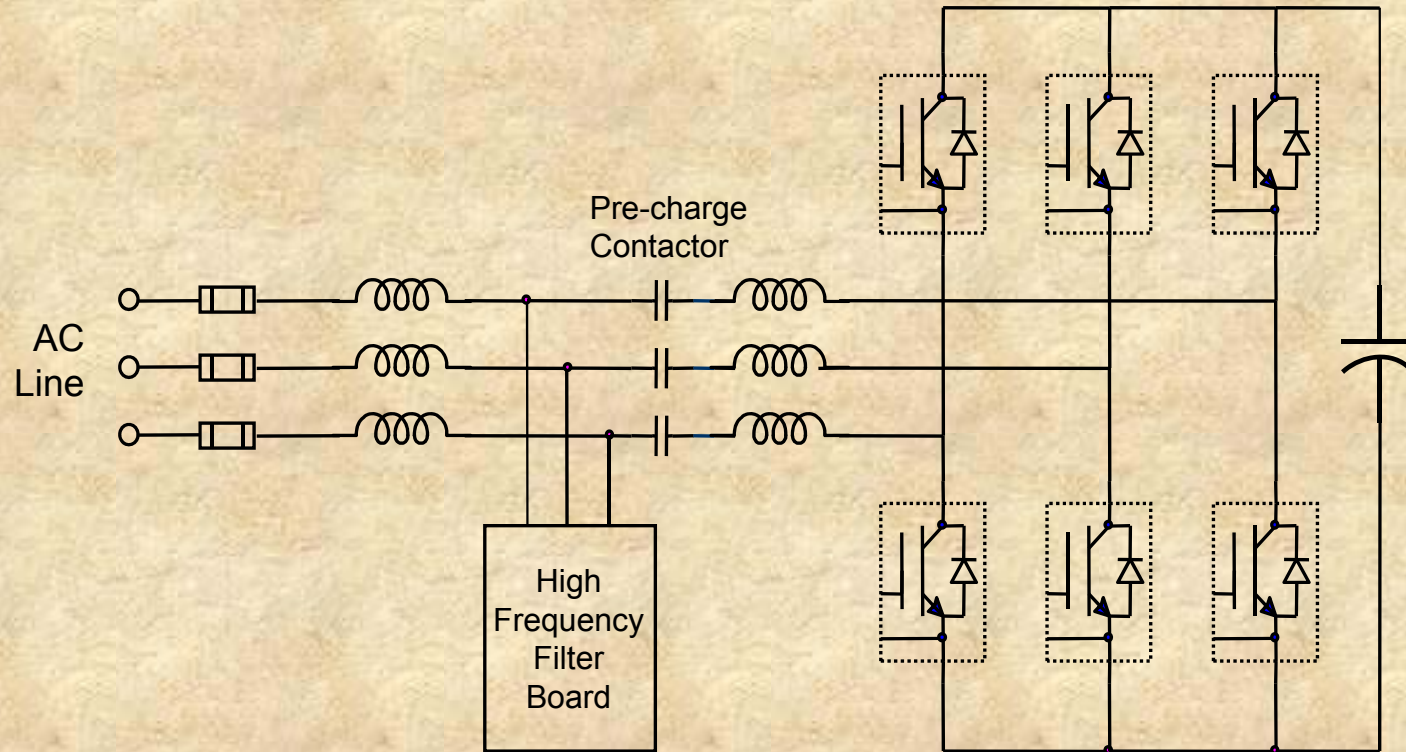
Filter Application



7 – Install Active Filter



The Active Filter



How it Works

