Generator System Considerations

CATERPILLAR®

TODAY'S WORK. TOMORROW'S WORLD.™

Generator Operation

- Exciter- Provides DC Current to the Rotor Windings
- Current Through These Windings Create Magnetic Flux
- This Magnetic Flux Generates an AC Voltage in Nearby Stator Windings when There is Relative Motion Between The Rotor and Stator
- The Regulator Senses This Output and “Controls” the Exciter Current

Types of Excitation

Self Excited: Uses The Output From The Main Generator To Supply it's Own Exciter Current.

Permanent Magnet: Furnishes Power To The Main Exciter, Thus Eliminating The Main Exciter Dependence on the Output Voltage. Essentially a "Mini-Generator"- **required to produce 300% current to trip down stream breakers.**

Winding Types

Random Wound- Use Coils of Round Wire

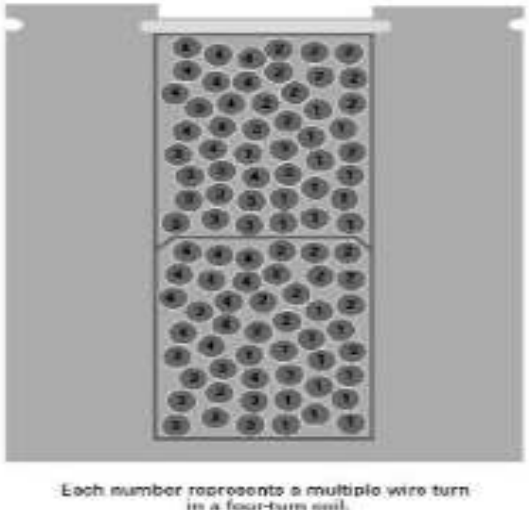
- Advantage: Material Cost Lower
- Used with lower power ratings
- Standby applications (low hour)
- Clean enviroment
- Low non linear loads

Form Wound – Use Square of Rectangular Wires

- Advantage : Strength – ROBUST DESIGN
- Superior Efficiency and Durability
- Used with high power ratings
- Prime power applications
- Dirty enviroments
- High non linear loads
- Disadvantage: Usually Impractical in smaller Generators

Winding Types

Random Winding



Each number represents a multiple wire turn in a four-turn coil.

- Copper
- Polyester Film
- Glass/Nomex/NMN Stick
- NMN Slot Liner
- Steel

Formed Winding

Each number represents a multiple wire turn in a four-turn coil.

- Copper
- Polyester Film
- Double Dacron Glass Overcoat
- Glass/Nomex/NMN Stick
- Mica/Polyester/Glass Tape
- NMN Slot Liner
- Steel

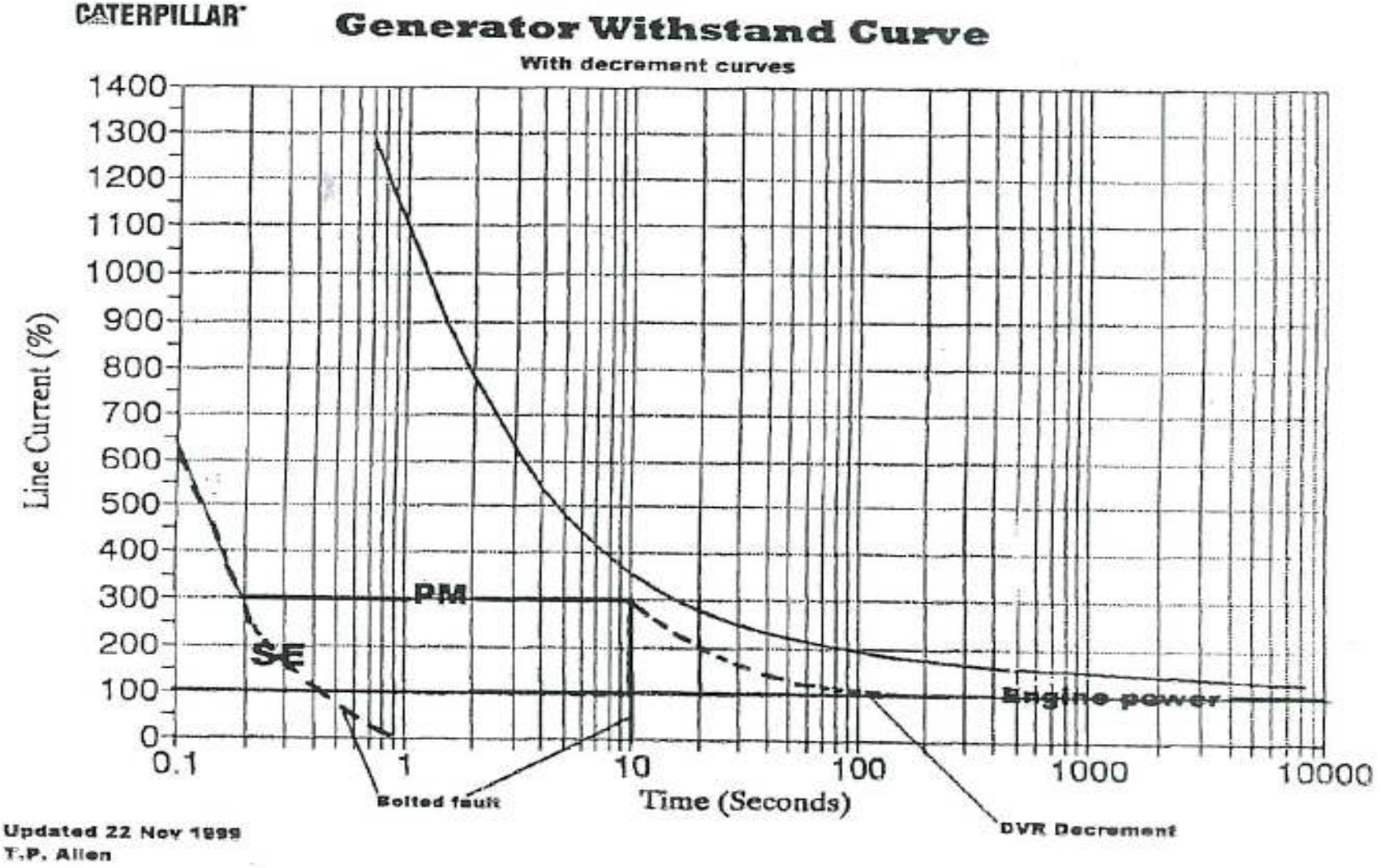
DECREMENT CURVE

The generator decrement current curve gives the

symmetrical current supplied by the generator for a three phase bolted fault at the generator terminals.

Generators equipped with the series boost attachment or generators with PM excitation system will supply 300% of rated current for at least 10 seconds.

TYPICAL GENERATOR WITHSTAND CURVE

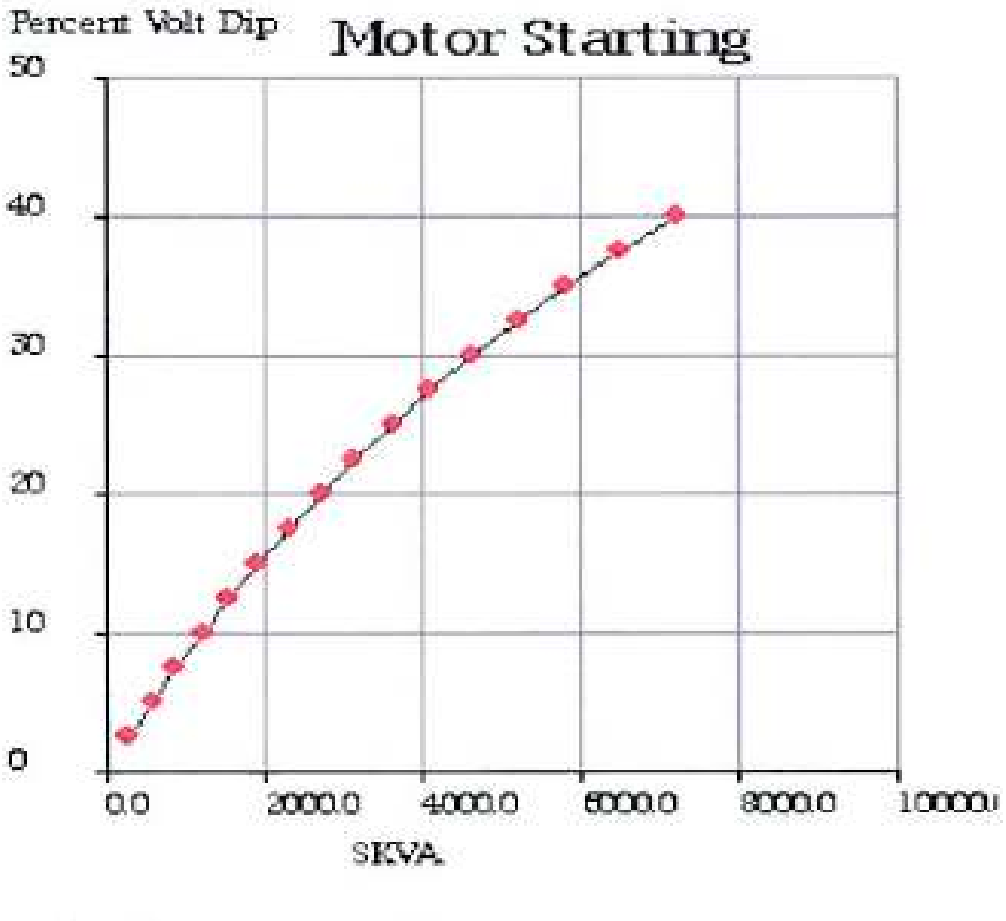


Motor Starting Capabilities

- SKVA at a Voltage Dip of _____%
- Satisfy starting SKVA and running loads when sizing a generator system
- How to increase SKVA
  - Oversize generator, not the engine $
  - Oversize the engine/generator package $$$$$
- Reduce SKVA required
  - Stagger Start loads (Timers, ATS'S)
  - Motor Starters
  - Compare using Cat Specsizer program
  - Both generator and the engine have a transient response as a result to a large motor start, therefore we model the engine and generator with the specsizer program. (not just the generator)

TMI SKVA DATA

SKVA	Percent Volt Dip
278	2.5
571	5.0
879	7.5
1,205	10.0
1,549	12.5
1,913	15.0
2,300	17.5
2,711	20.0
3,148	22.5
3,614	25.0
4,113	27.5
4,647	30.0
5,220	32.5
5,838	35.0
6,505	37.5
7,228	40.0



Power Factor

- Amps = watts / volts x PF x 1.732
- Power Factor = watts / volt x amps x 1.732
- Unity PF : Resistive, Power Factor of 1
- 0.8 Power Factor (industry standard)

✓ Caution: Sizing to Amps only (know the Power Factor)

- Effects of low power factor - Generator (not engine) overload

Mechanical Performance of Engine

- **Utility Bus versus Engine**
- **Load Changes, Engine Governor responds, speed and voltage dips**
- **Engine Speed 1800 RPM – 60 Hertz, 4 Pole Generator**

EXHAUST SYSTEMS

- **System Backpressures** (typical 27”H_2O)
- **Considerations**
  - Silencer size
  - Distance of pipe run
  - Pipe size
  - Pipe fittings- ell’s, 45 deg ells, etc
- **Corrections**
  - Larger silencers
  - Larger pipe
- ***Discharge away from air intakes

Definitions

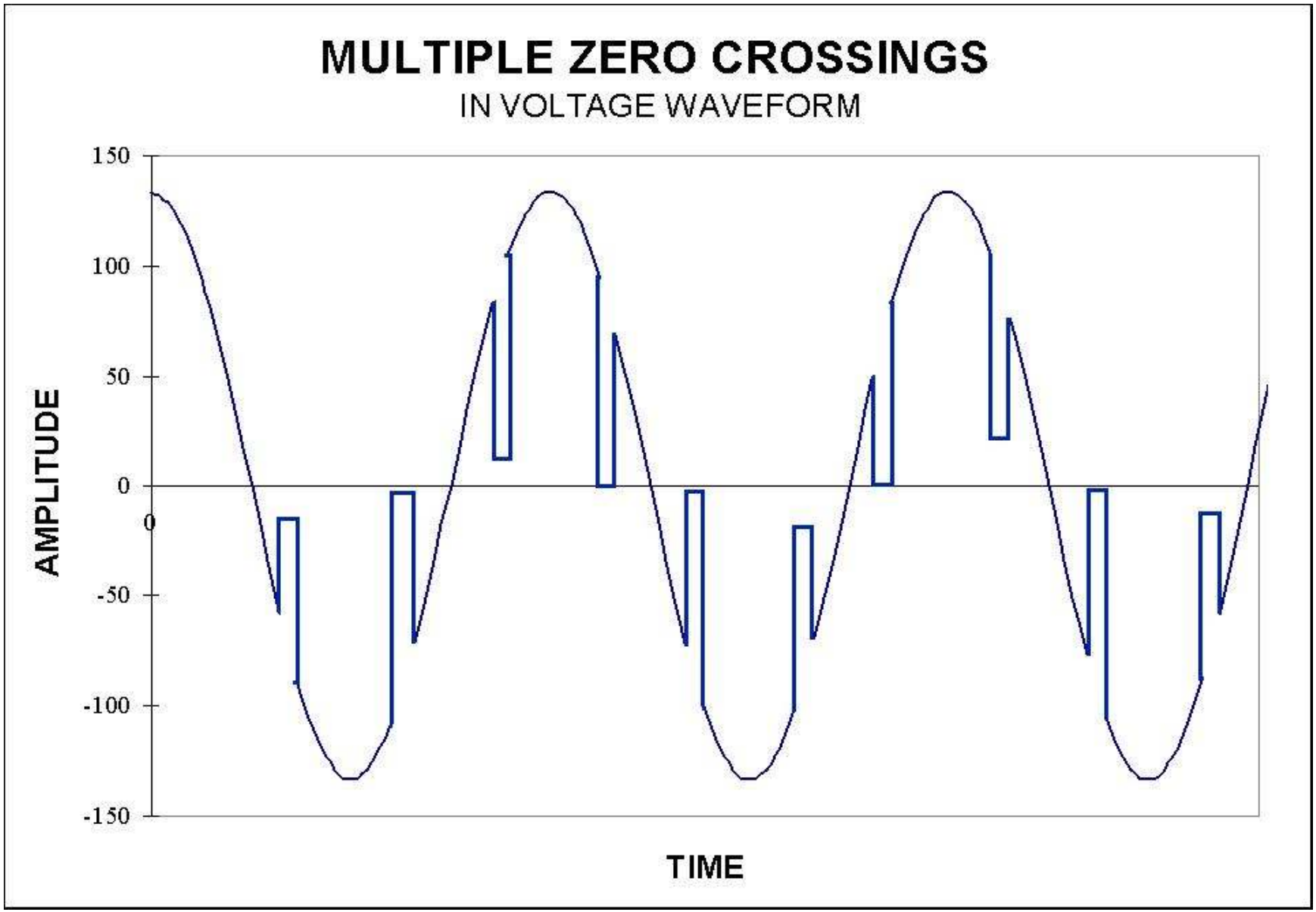
- Non-Linear Loads
  - Load current is not proportional to instantaneous voltage
- Harmonics
  - Normally comprising odd multiples of the fundamental frequency.

Typical Linear Loads

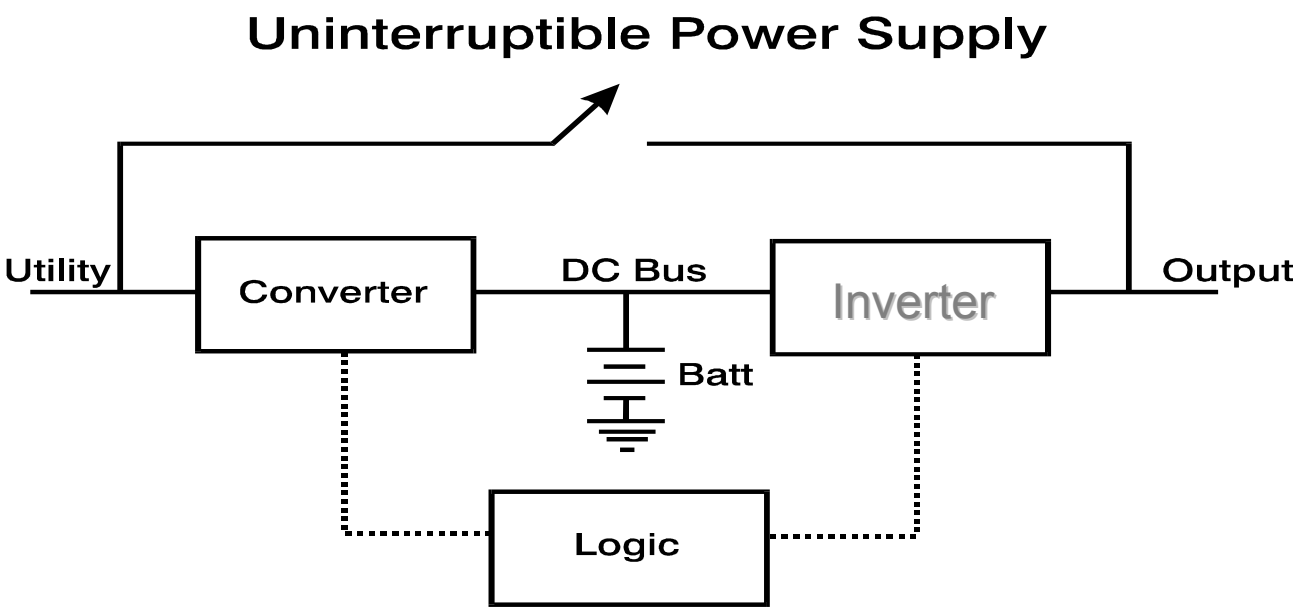
- Resistance Heaters or Load Banks
- Incandescent Lights
- Transformers (not saturated)
- Induction and Synchronous Motors
- Electromagnetic Devices

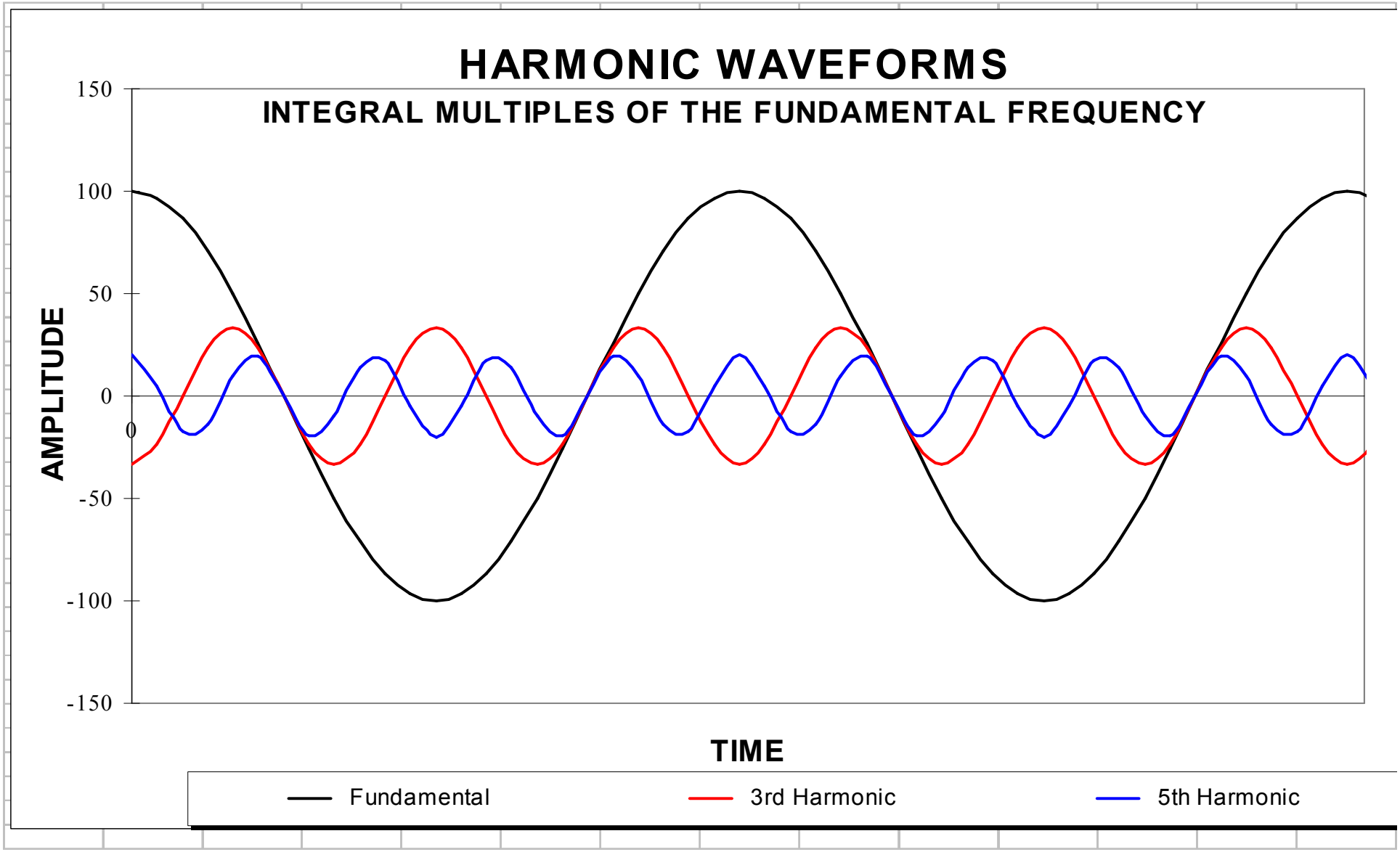
Typical Non-Linear Loads

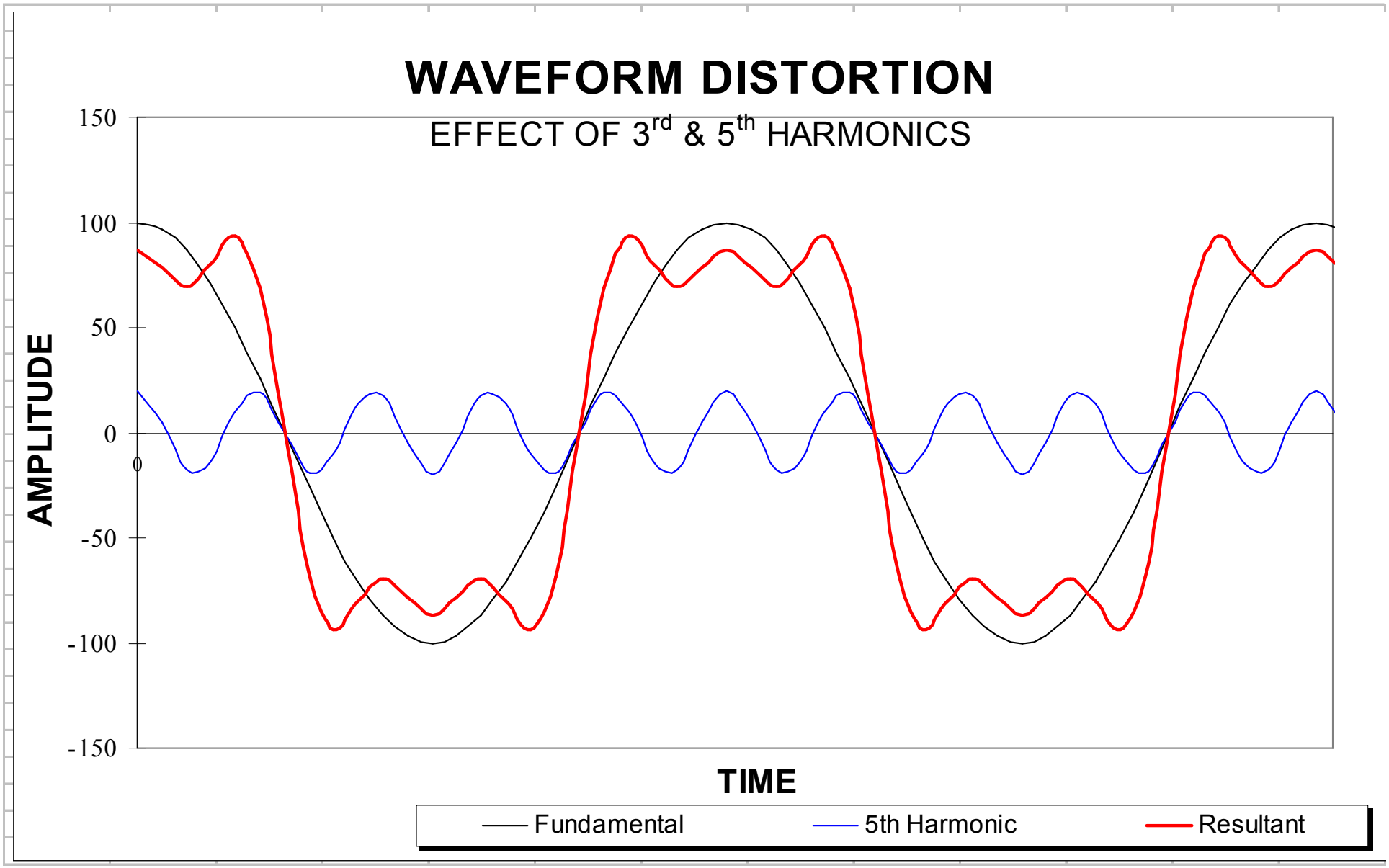
- Silicon Controlled Rectifiers (SCR)
- Uninterruptible Power Supply (UPS)
- Computers
- Transformers (saturated)
- Variable Speed Drives (VSD)
- Variable Frequency Drive (VFD)
- Fluorescent & Gas Discharge Lighting
- X-Ray Machines


MULTIPLE ZERO CROSSINGS
IN VOLTAGE WAVEFORM
150
100
50
0
0
-50
-100
-150
AMPLITUDE
TIME

UPS Systems


Uninterruptible Power Supply
Utility
Converter
DC Bus
Inverter
Output
Batt
Logic


HARMONIC WAVEFORMS
INTEGRAL MULTIPLES OF THE FUNDAMENTAL FREQUENCY
150
100
50
0
-50
-100
-150
AMPLITUDE
0
TIME
Fundamental
3rd Harmonic
5th Harmonic


WAVEFORM DISTORTION
EFFECT OF 3rd & 5th HARMONICS
150
100
50
0
-50
-100
-150
0
AMPLITUDE
TIME
Fundamental
5th Harmonic
Resultant

- Non-Linear loads cause system problems
  - Prepare
  - Educate
- Proper system design can avoid or eliminate problems
- Get complete load details when sizing generator and generator set
- Apply proper generator and voltage regulator