# Welcome!

## Motor Control Maintenance

## DRV Inc. Scott Hinsch and Pat Smith

DRV INCORPORATED
"PEOPLE who care, SOLUTIONS that work!"

17406 Royalton Rd.
Suite A #109
Strongsville, Ohio 44136
(440) 345-6378 Office
(216) 385-1395 Cell
psmith@drv-inc.com

## We're Glad You're Here!

Please, put your cell phones on vibrate during sessions, and take calls to the hallway

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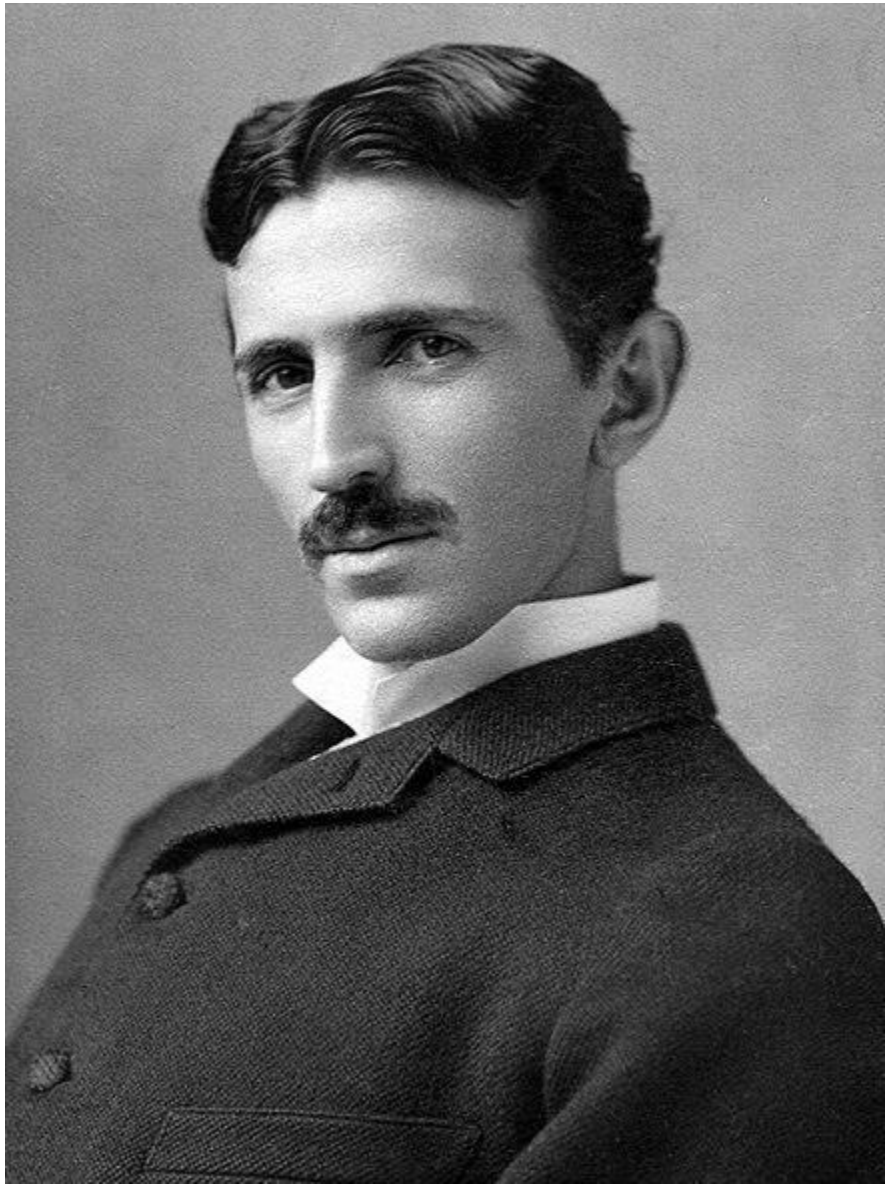
# AC Induction Motors

G. Ferraris

**GALILEO FERRARIS**

nato a Livorno Vercellese (Piemonte) il 31 ottobre 1847
morto a Torino il 7 febbraio 1897.

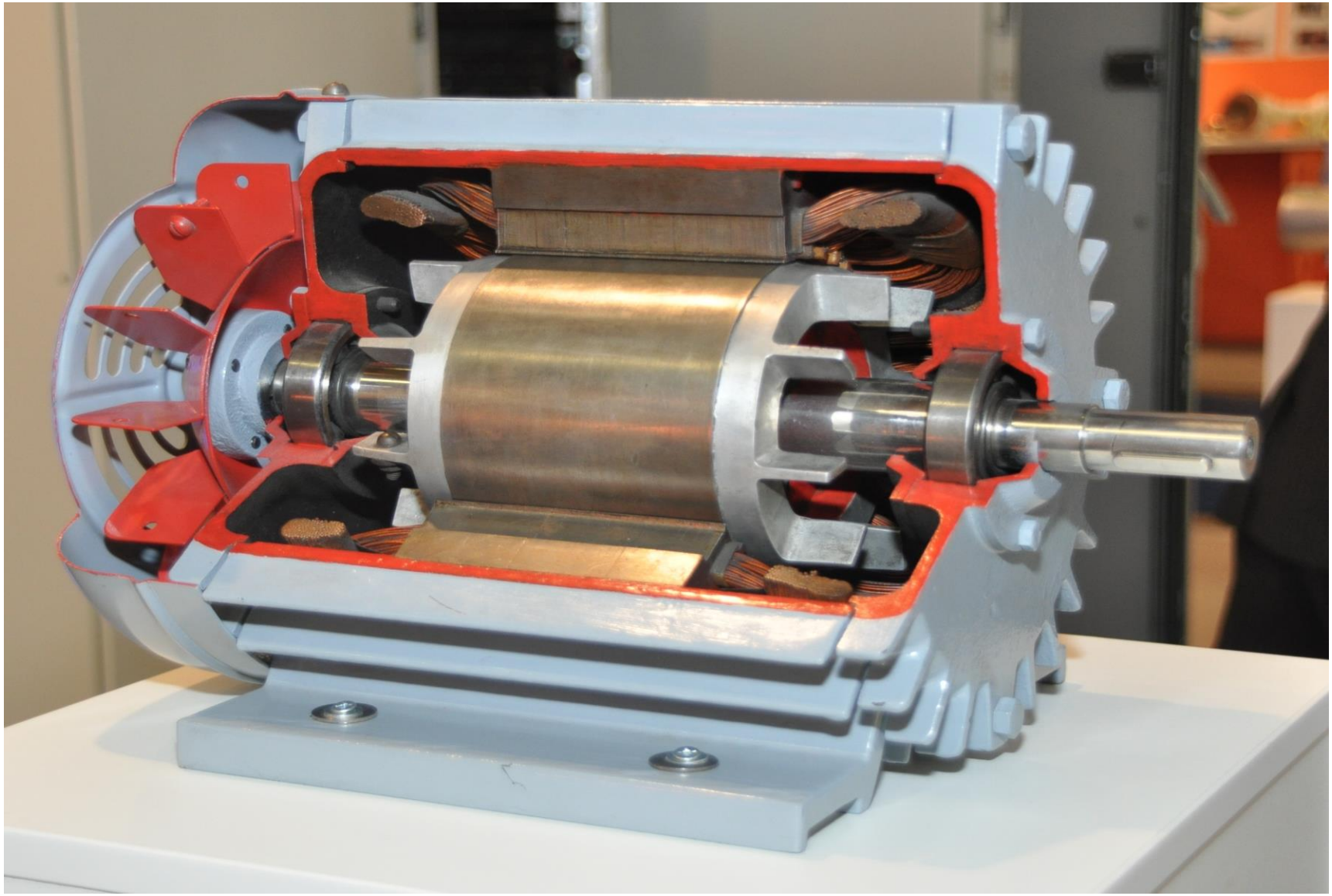
*Da una fotografia di Gibson di Chicago.*

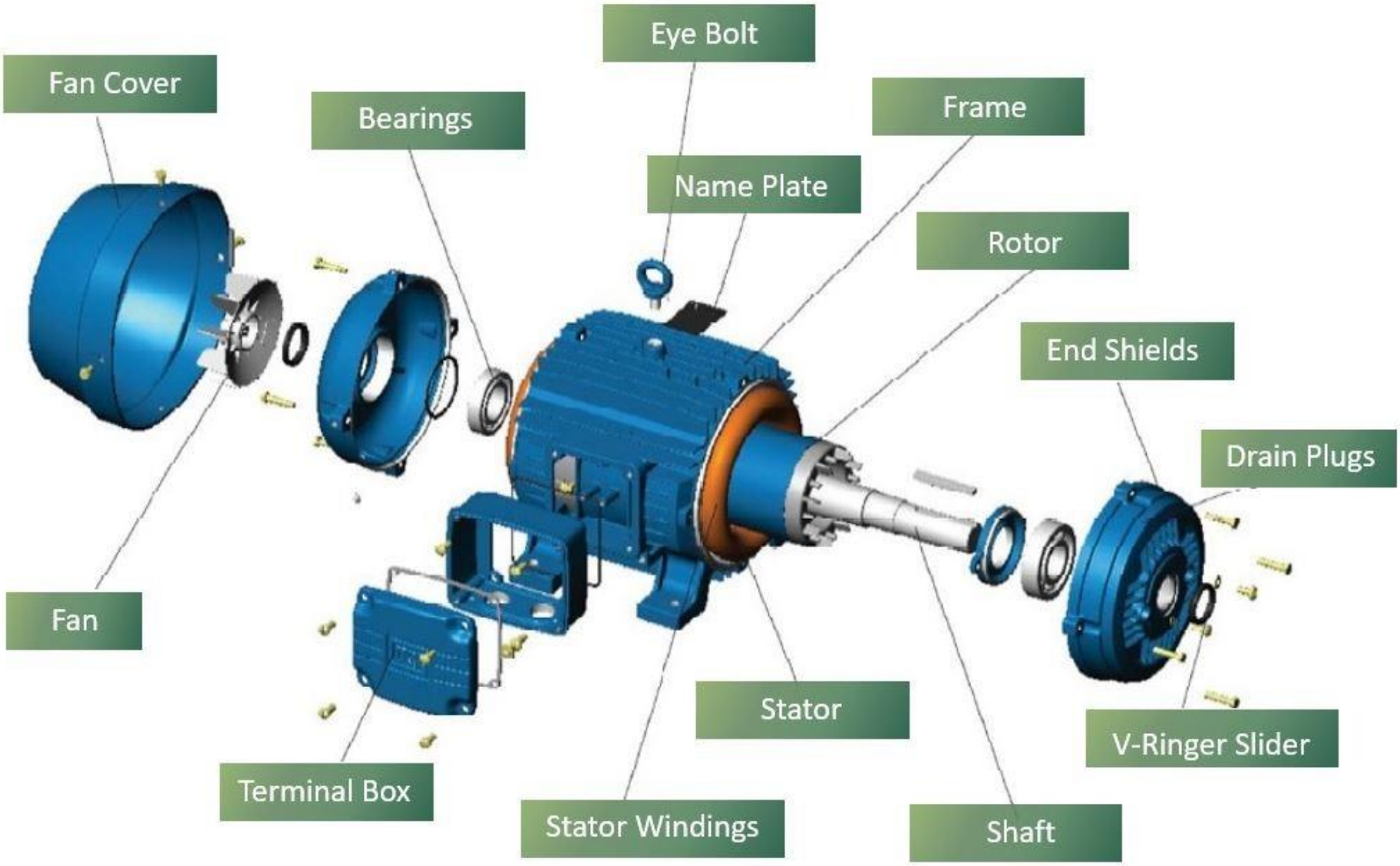


# AC Induction Motors

- Simple design, rugged, low-price, easy to maintain
- Large range of power ratings, fractional to tens of thousands of HP
- Mostly run at constant speed from zero to full load
- Speed is power source frequency dependent
  - Requires a variable-frequency power-electronic drive for optimal speed control

# Induction Motors




Eye Bolt
Fan Cover
Bearings
Frame
Name Plate
Rotor
End Shields
Drain Plugs
Fan
Stator
V-Ringer Slider
Terminal Box
Stator Windings
Shaft

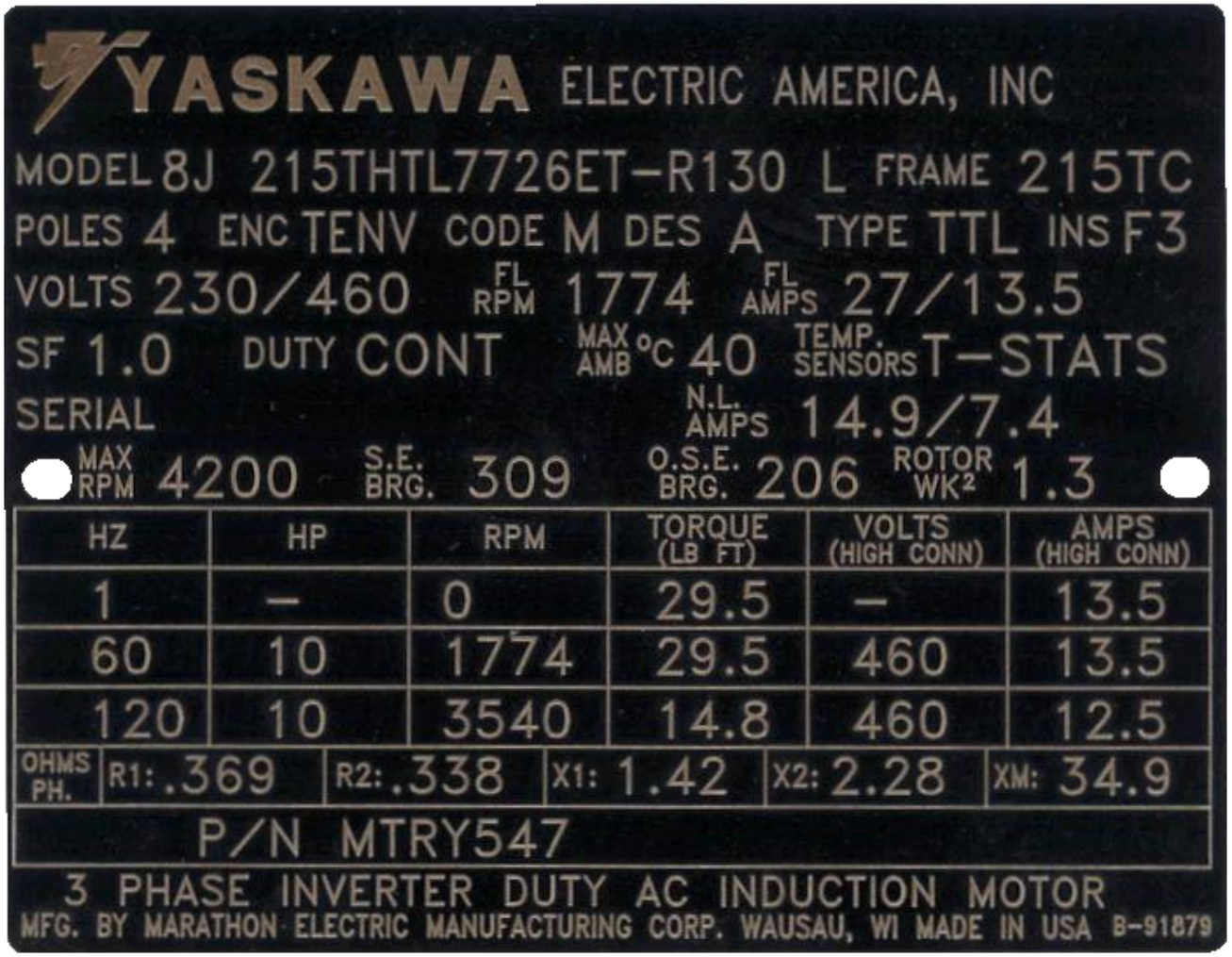
# Poles & Synchronous RPM @ 60Hz

| Magnetic Poles | Synchronous RPM |
|---|---|
| 2 | 3600 |
| 4 | 1800 |
| 6 | 1200 |
| 8 | 900 |

$$\frac{7200}{P} = \text{Synchronous RPM}$$

$$\frac{7200}{\text{Synchronous RPM}} = P$$

# Motor Nameplate Data



YASKAWA ELECTRIC AMERICA, INC

MODEL 8J 215THTL7726ET-R130 L FRAME 215TC

POLES 4 ENC TENV CODE M DES A TYPE TTL INS F3

VOLTS 230/460 FL RPM 1774 FL AMPS 27/13.5

SF 1.0 DUTY CONT MAX AMB °C 40 TEMP. SENSORS T-STATS

SERIAL N.L. AMPS 14.9/7.4

MAX RPM 4200 S.E. BRG. 309 O.S.E. BRG. 206 ROTOR WK² 1.3

| HZ | HP | RPM | TORQUE (LB FT) | VOLTS (HIGH CONN) | AMPS (HIGH CONN) |
|---|---|---|---|---|---|
| 1 | – | 0 | 29.5 | – | 13.5 |
| 60 | 10 | 1774 | 29.5 | 460 | 13.5 |
| 120 | 10 | 3540 | 14.8 | 460 | 12.5 |

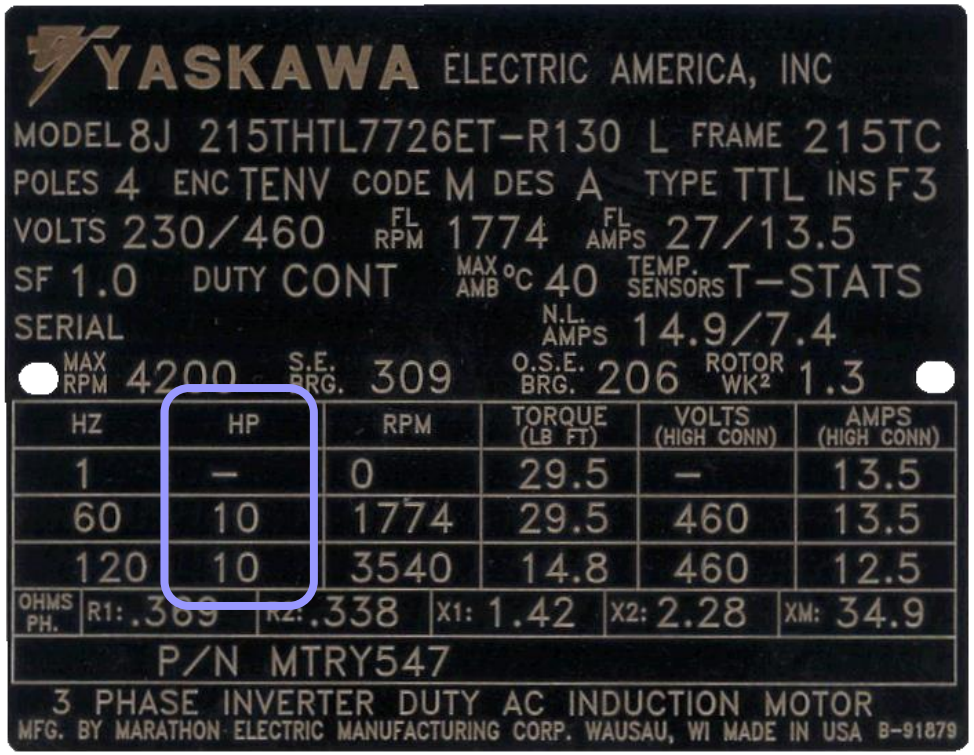
| OHMS PH. | R1: .369 | R2: .338 | X1: 1.42 | X2: 2.28 | XM: 34.9 |
|---|---|---|---|---|---|

P/N MTRY547

3 PHASE INVERTER DUTY AC INDUCTION MOTOR

MFG. BY MARATHON ELECTRIC MANUFACTURING CORP. WAUSAU, WI MADE IN USA B-91879

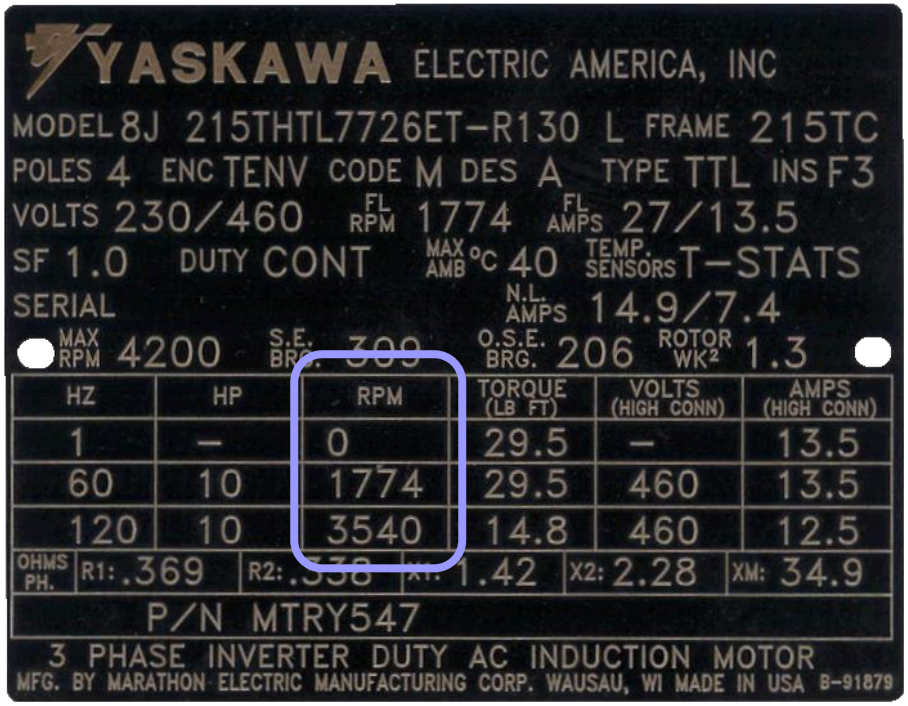
# Understanding the Nameplate




HP- Horsepower

- The horsepower figure stamped on the nameplate is the horsepower the motor is rated to develop when connected to a circuit of the voltage, frequency and number of phases specified on the motor nameplate.

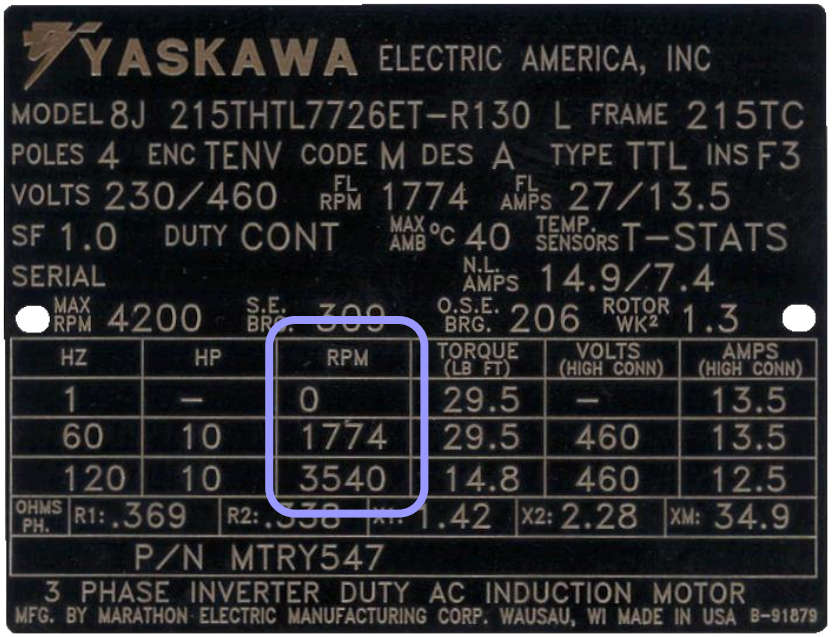
# Understanding the Nameplate




RPM - Revolutions per Minute

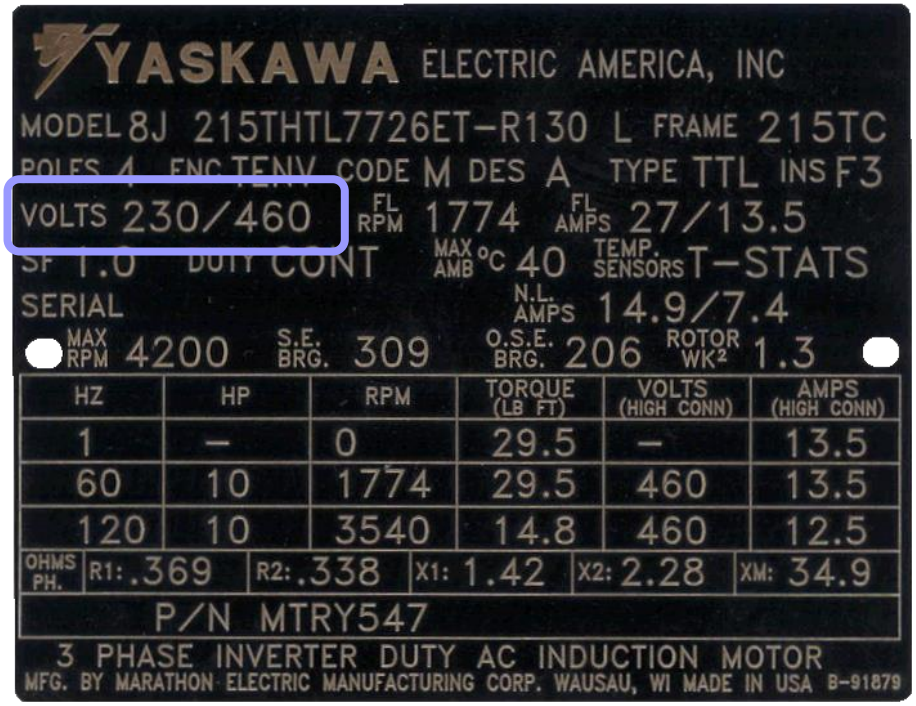
- The RPM value represents the approximate speed at which the motor will run when properly connected and delivering its rated output

# Understanding the Nameplate




| Poles | Synchronous RPM | Typical Nameplate RPM |
|---|---|---|
| 2 | 3600 | 3540 |
| 4 | 1800 | 1774 |
| 6 | 1200 | 1140 |
| 8 | 900 | 850 |

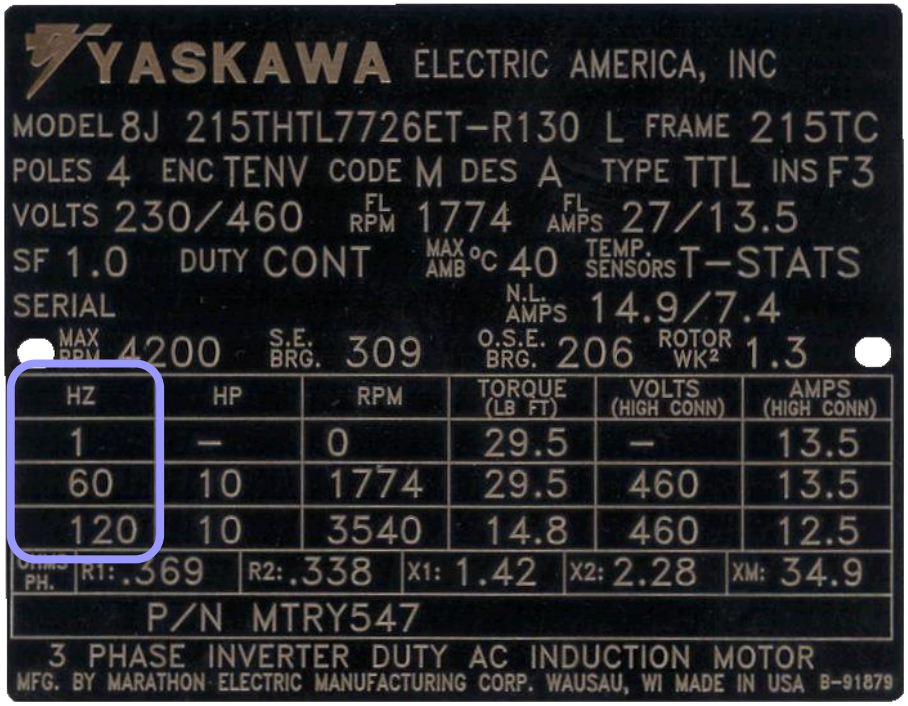
# Understanding the Nameplate




## Voltage

- The rated voltage figure on the motor nameplate refers to the voltage of the supply circuit to which the motor should be connected, to produce rated horsepower and RPM.

# Understanding the Nameplate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VOLTS 230/460 FL RPM 1774 FL AMPS 27/13.5

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MAX RPM 4200 S.E. BRG. 309 O.S.E. BRG. 206 ROTOR WK² 1.3

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OHMS PH. R1: .369 R2: .338 X1: 1.42 X2: 2.28 XM: 34.9

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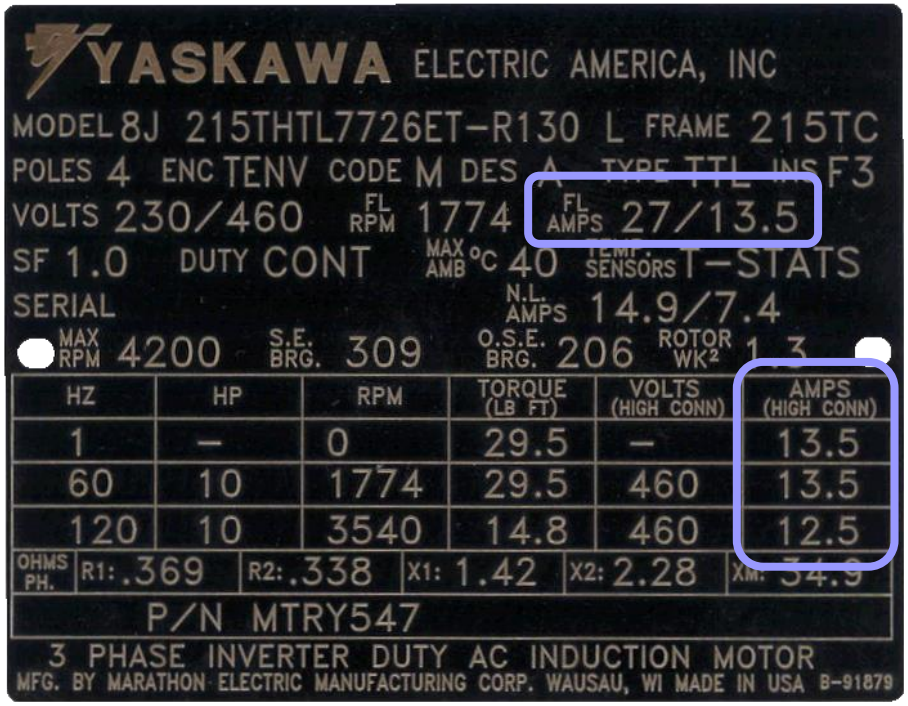
Hz-Frequency

- The frequency figure on the motor nameplate describes the alternating current system frequency that must be applied to the motor to achieve rated speed and horsepower.

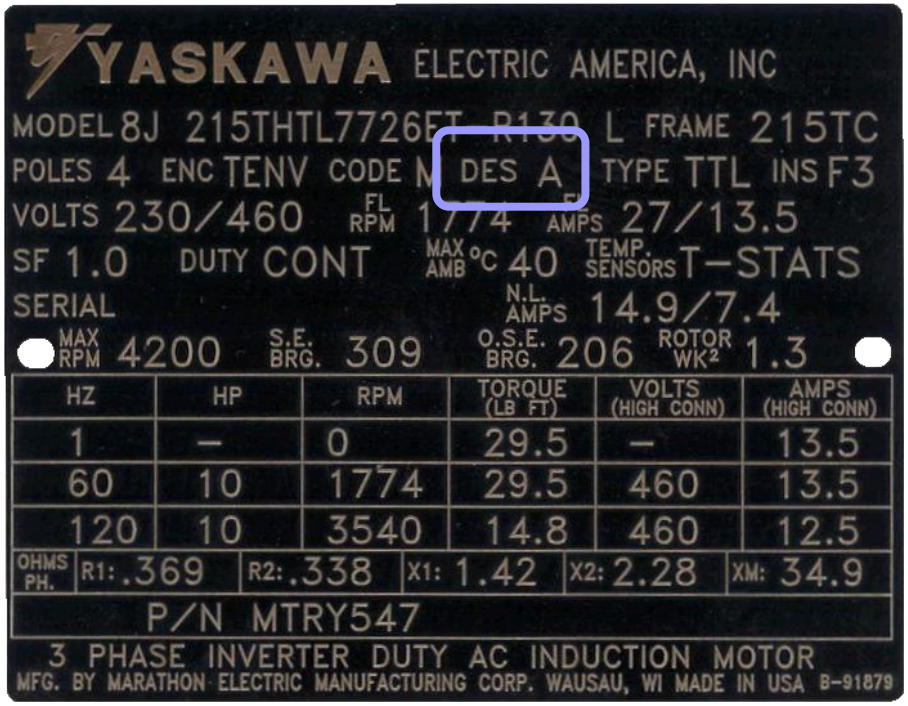
# Understanding the Nameplate




## Amps

- The amp figure on the motor nameplate represents the approximate current draw by the motor when developing rated horsepower on a circuit of the voltage and frequency specified on the nameplate.

# Understanding the Nameplate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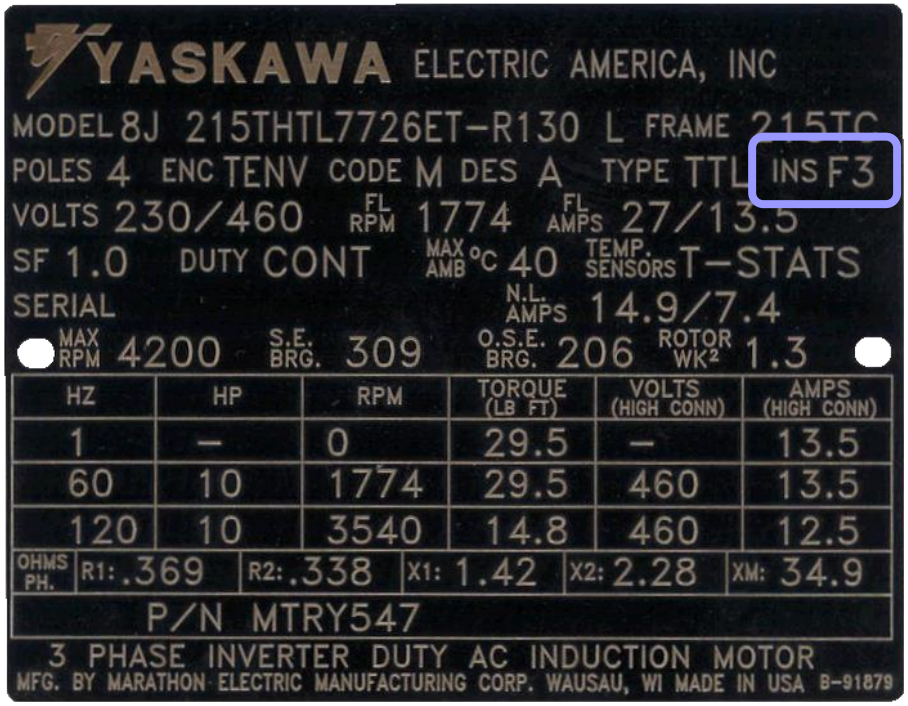
NEMA Design

- The NEMA Design rating specifies the speed torque curve that will be produced by the motor.

# Understanding the Nameplate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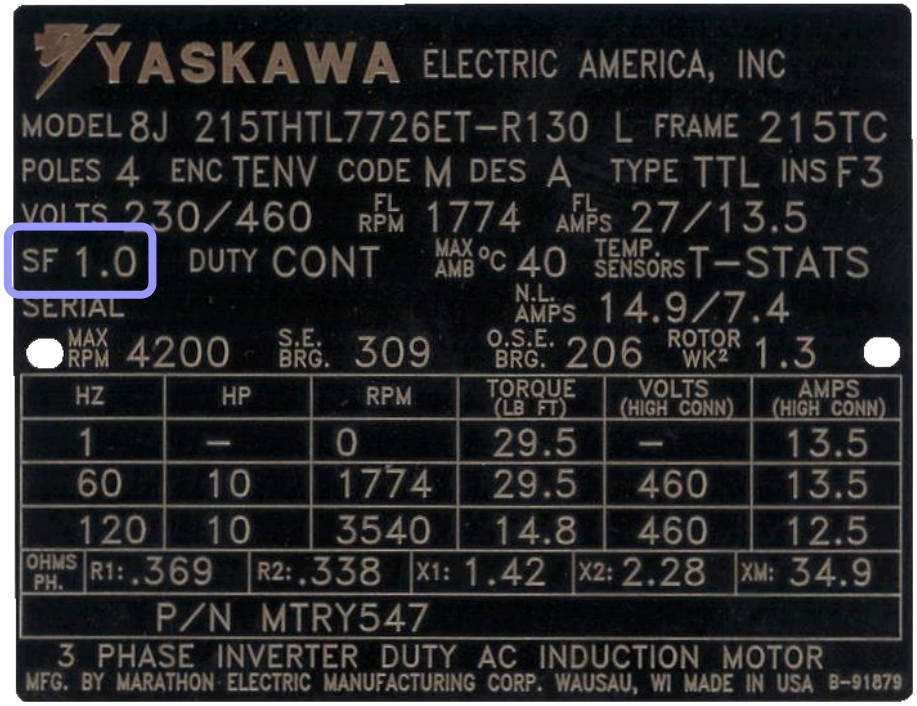
## Insulation Class

- The insulation class letter designates the amount of allowable temperature rise based on the insulation system and the motor service factor.

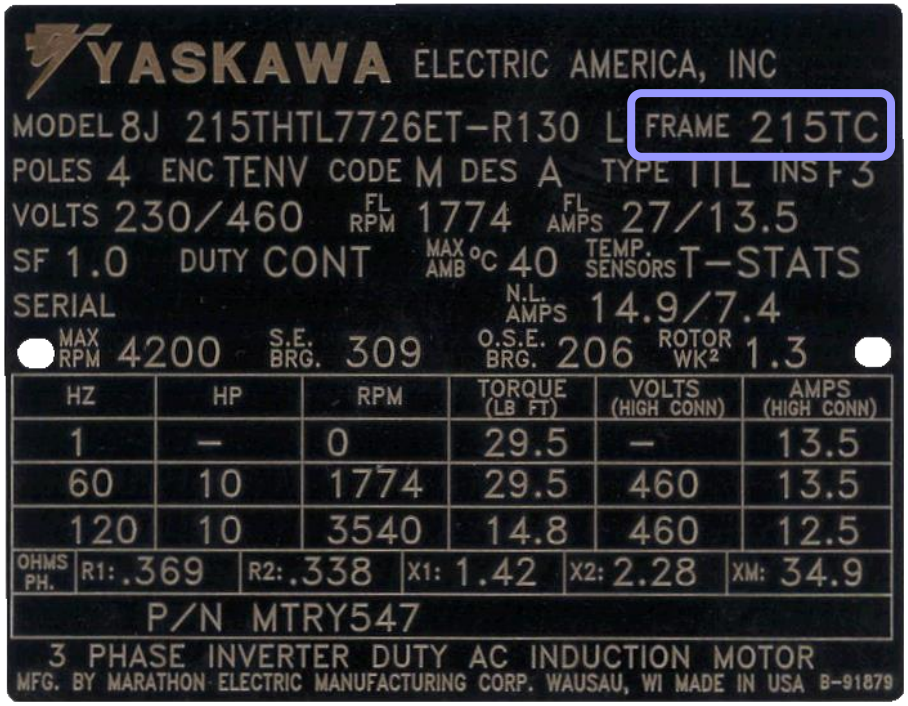
# Understanding the Nameplate




S.F. - Service Factor

- The number by which the horsepower rating is multiplied to determine the maximum safe load that a motor may be expected to carry continuously
- Example - a 10HP motor with a service factor of 1.15 will deliver 11.5 horsepower continuously without exceeding the allowable temperature rise of its insulation class

# Understanding the Nameplate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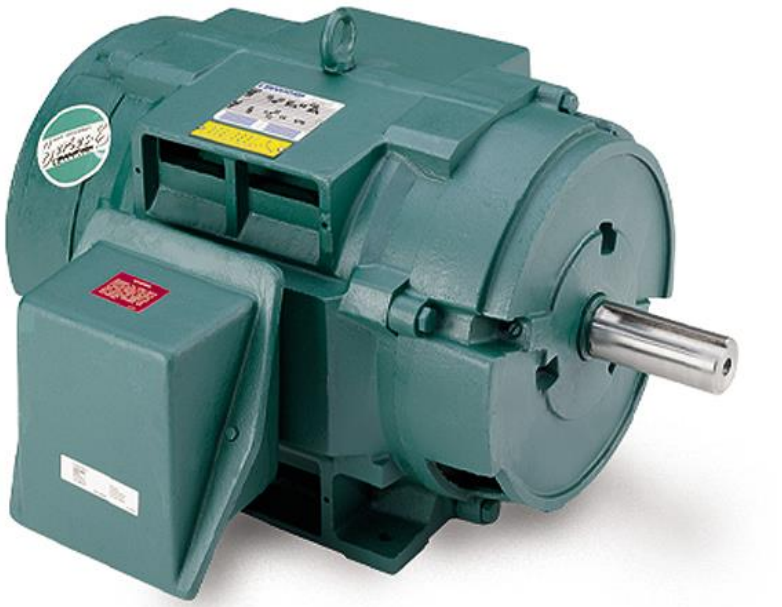
## Frame

- The frame designation refers to the physical size of the motor as well as certain construction features such as the shaft and mounting dimensions.

# Types of Motor Enclosures

## ODP

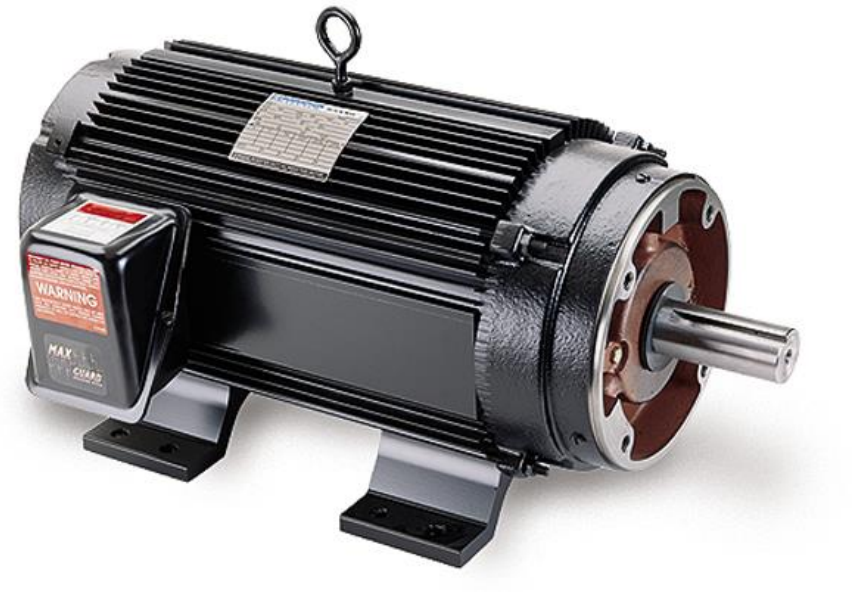
- Open drip-proof
- Ventilating openings permit passage of external cooling air over and around the windings of the motor. Small degree of protection against liquid or solid particles entering the enclosure.



# Types of Motor Enclosures

## TENV

- Totally enclosed non-ventilated
- Totally enclosed enclosure with no means of external cooling.



# Types of Motor Enclosures

## TEFC

- Totally enclosed fan-cooled
- Totally enclosed enclosure with external cooling means, such as a shaft connected fan

# Types of Motor Enclosures

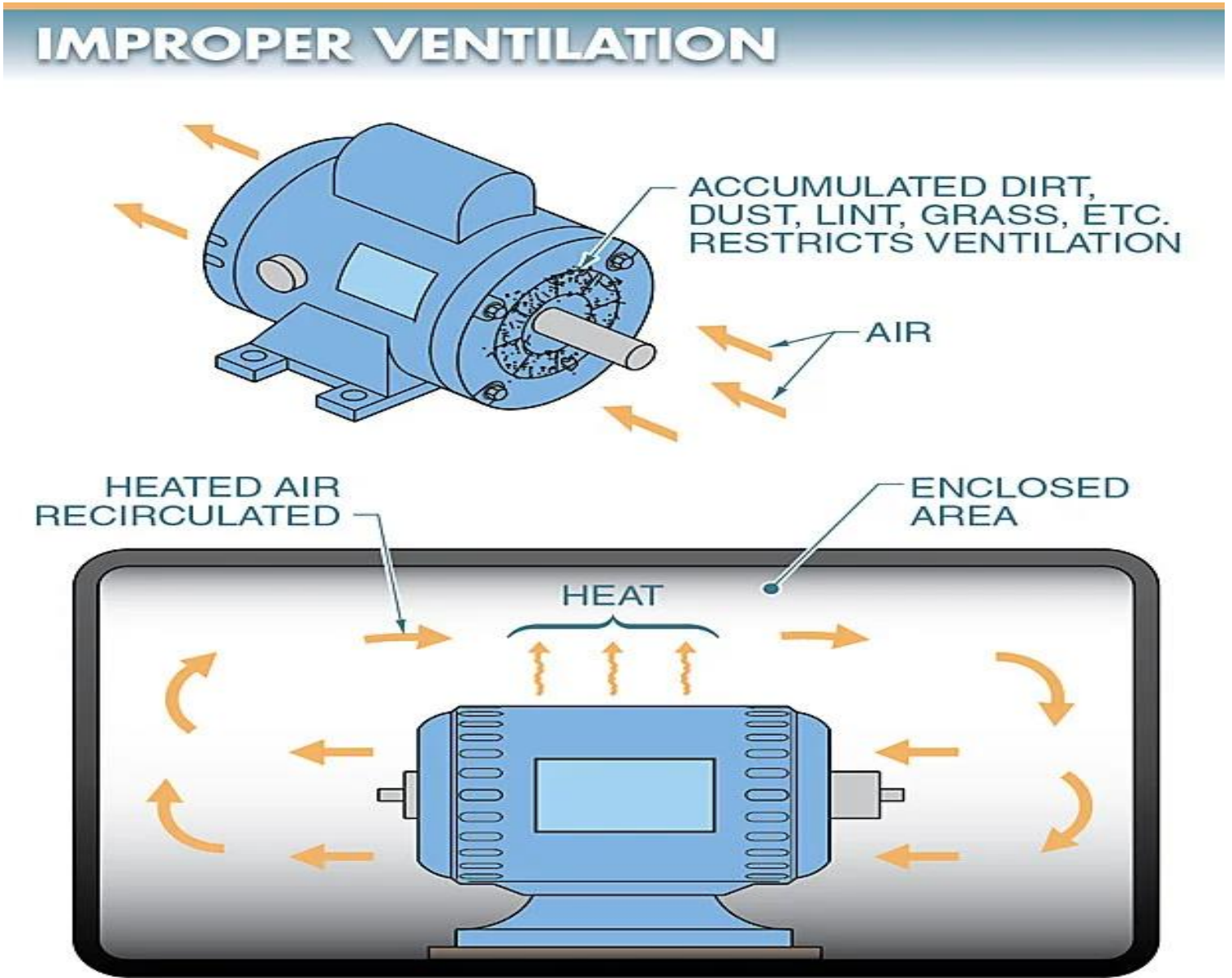
## TEBC

- Totally enclosed blower-cooled

- Totally enclosed enclosure with external cooling means such as a separately controlled motor/blower

# Maintenance

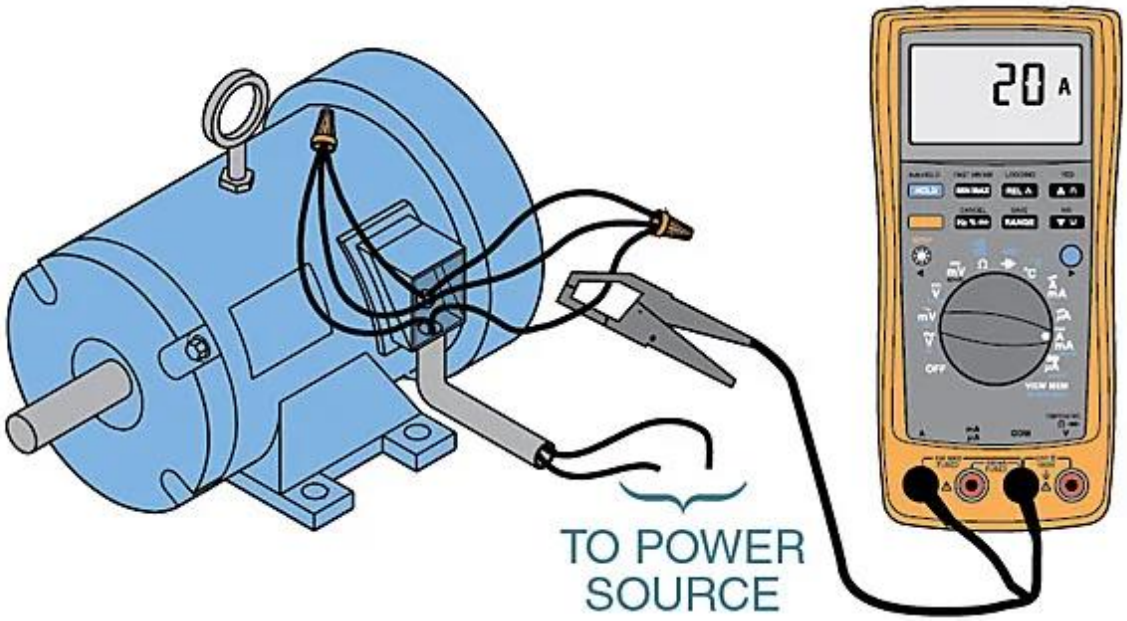
# Motor Maintenance



# MOTOR CURRENT READINGS

| Rated Current of Motor | Meter Reading | | |
|---|---|---|---|
| | Motor Underloaded | Motor Fully Loaded | Motor Overloaded |
| 20 A | 12 A | 20 A | 22 A |

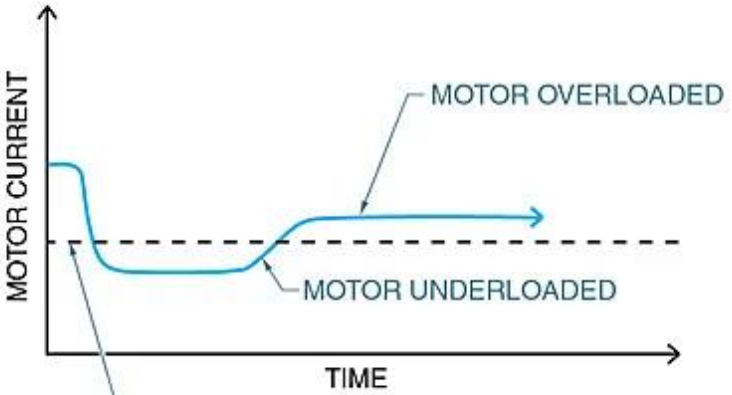
| NAMEPLATE LISTED VALUE | 0% TO 95% OF LISTED VALUE | 95% TO 105% OF LISTED VALUE | 105% + OF LISTED VALUE |
|---|---|---|---|



# MOTOR OVERLOADING

*Electrical Apparatus Service Association, Inc.*

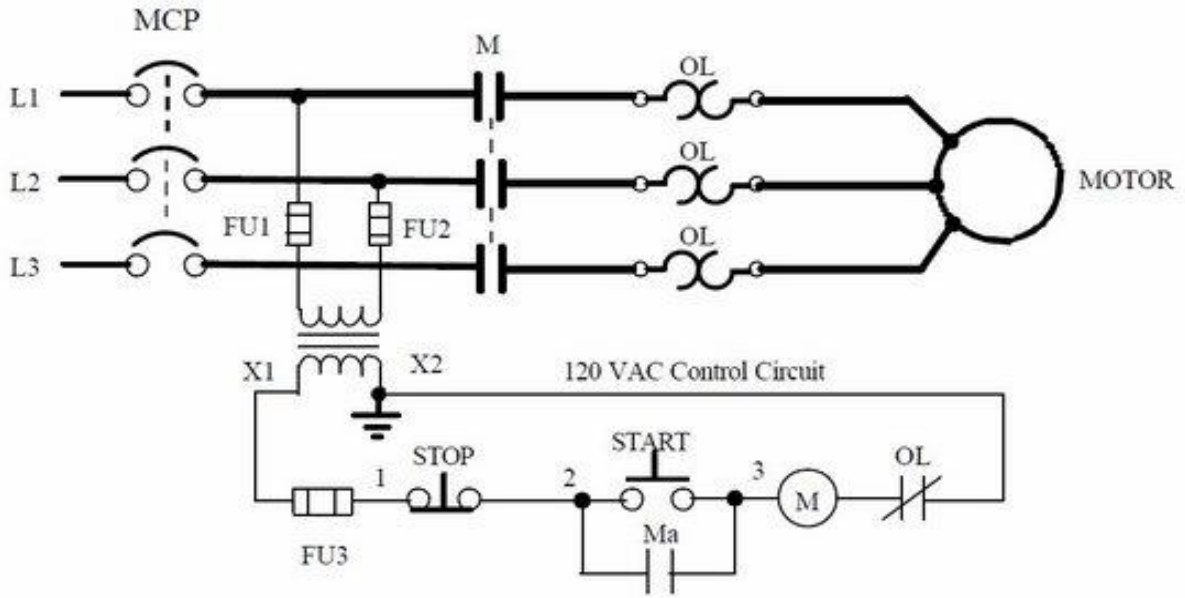
ALL WINDINGS
EVENLY BLACKENED



# Motor Starter

# Motor Starter

- What is a motor starter?

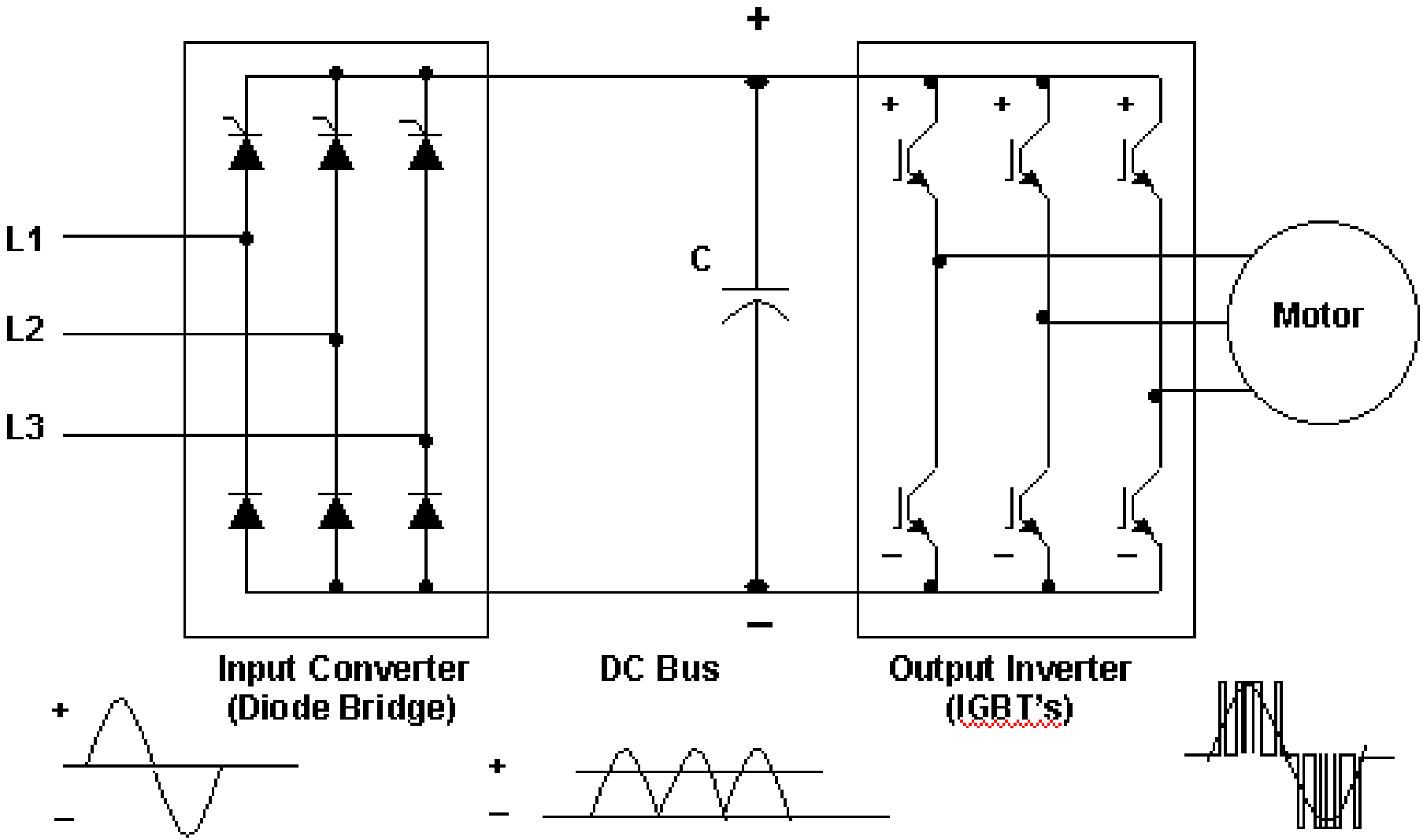


# Motor Starter Maintenance. What needs checked?

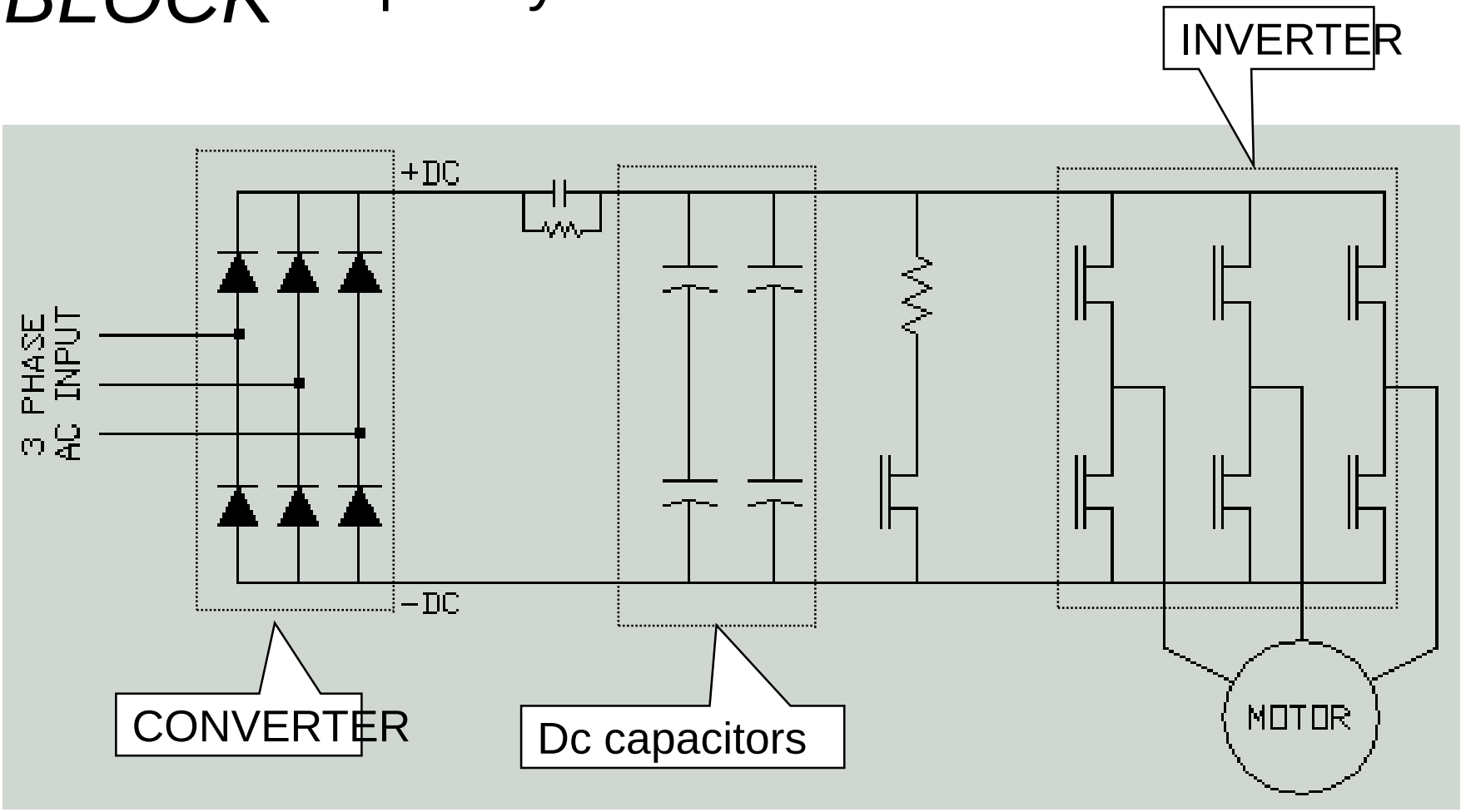
# VFD BASICS


YASKAWA
P1000
DIGITAL OPERATOR JVOP-180
ALM
F1
F2
ESC
LO RE
RESET
ENTER
RUN
STOP
CIMR-PU4A0004FAA
400V 3PHASE 4.1A/3.4A
WARNING
AVERTISSEMENT
CHARGE

# Power Diagram of VFD

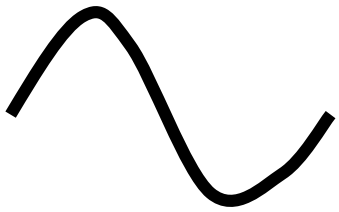


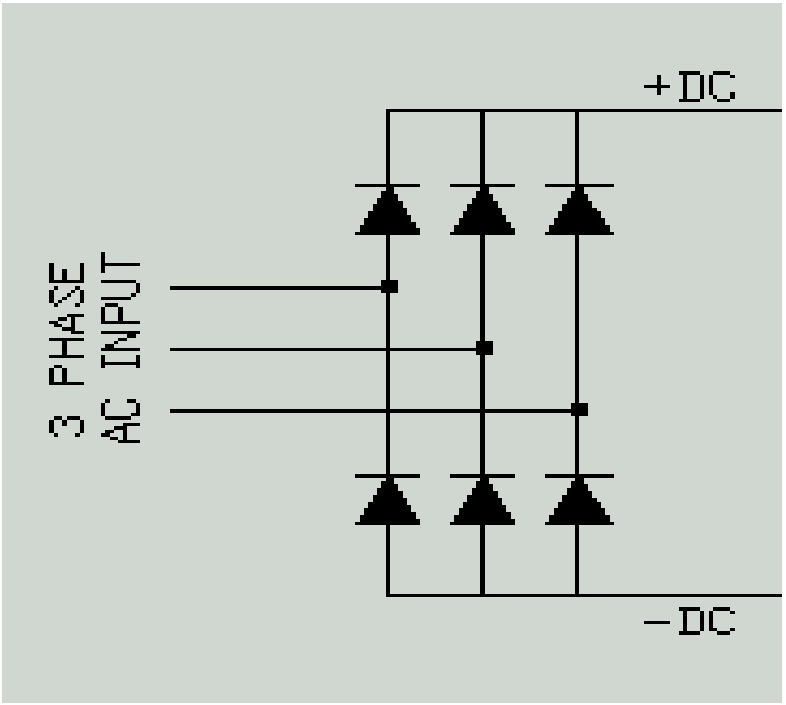
# *SOLID STATE*
## Variable Frequency CONTROL *BLOCK*

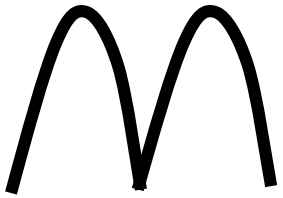


# Converter

Converts AC power to DC power



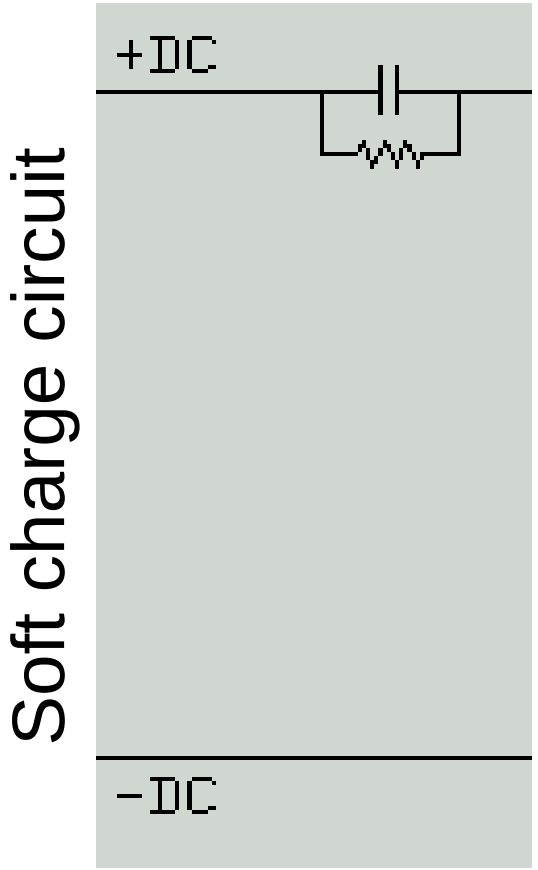


DC Bus = RMS x 1.414

# *Pre-charge or Soft Charge Circuit*

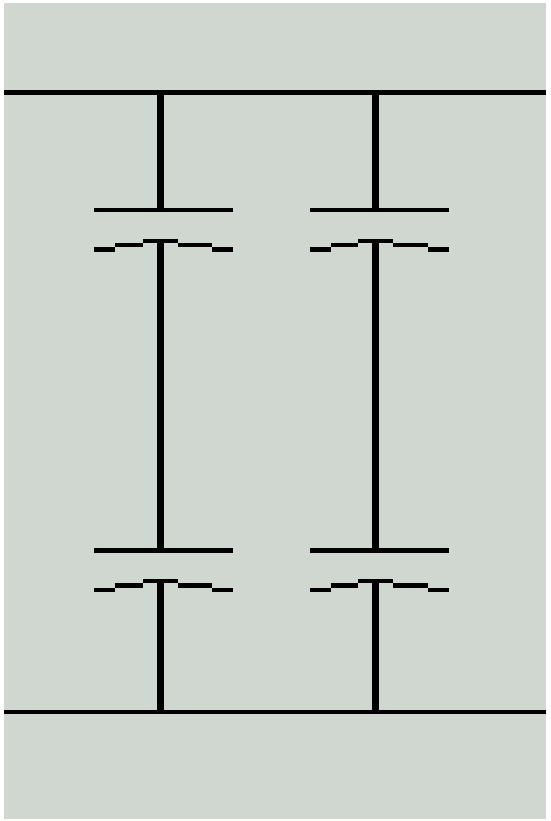
- At start up the discharged caps look as a dead short to the AC line.
- The resistor allows the caps to charge softly and prevent high charging currents



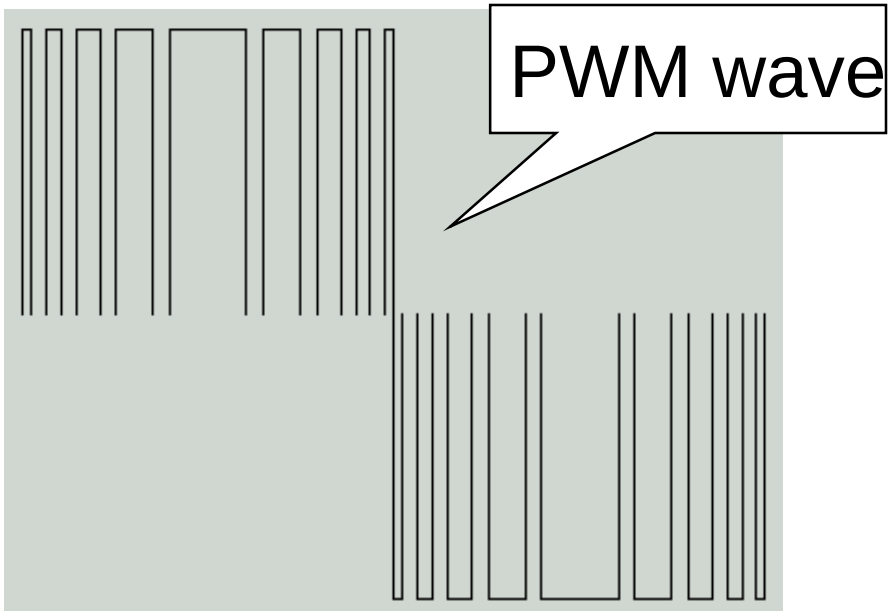
# *DC Bus*

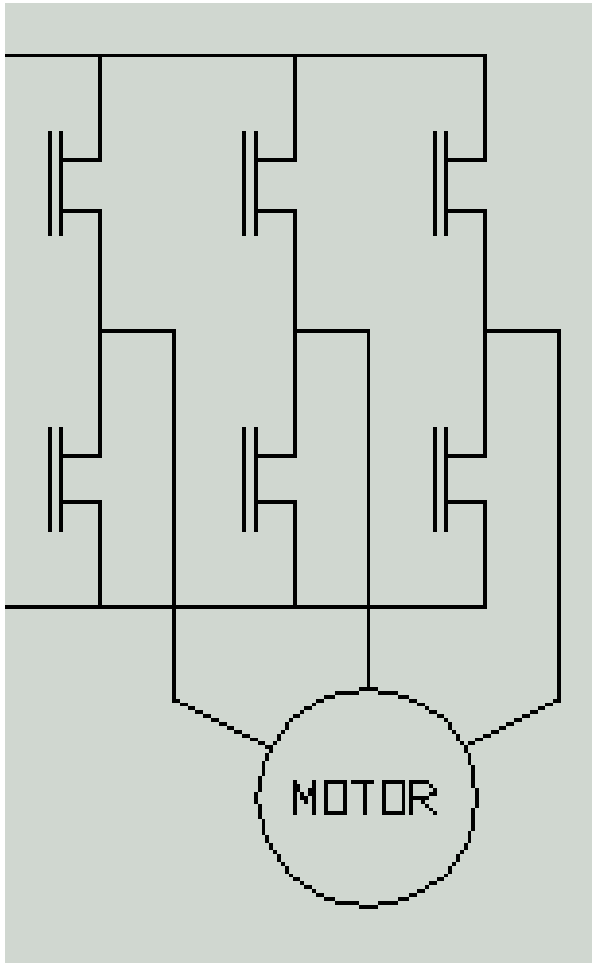
VFC Sections

- …FILTERS THE VOLTAGE
- …STORES POWER FOR LOAD



# *Inverter*
## VFC Sections



# *Test Equipment*
## Tools & Safety Issues

- **Electronic Multi-meters**
  - Used to Measure Voltage, Current & Resistance
- **“Clamp” Current Meter**
  - Used to Measure Large AC & DC Currents
- **Digital Oscilloscope**
  - Required for “real time” voltage & Current Measurements

# *Electronic Multi-meters*
## Tools & Safety Issues

- **Minimum Required Features**
  - Category III 1000v
  - AC to 750v
  - True RMS w/Crest Factor = 3
  - DC to 1000v
  - Resistance
  - Diode Check
  - Min/Max/Avg. Record
  - Optional
    - Frequency
    - Temperature


Tektronix TX1


Fluke 87-III

# *"Clamp"* ***Current Meter***

## Tools & Safety Issues

- **Minimum Required Features**
  - Category III 600v
  - AC current - 45 to 400hz
  - True RMS w/Crest Factor = 3
  - Optional
    - Connect to DMM/Oscilloscope
    - Min/Max/Avg. Record
    - Frequency
    - DC Current


# *Portable Oscilloscopes*

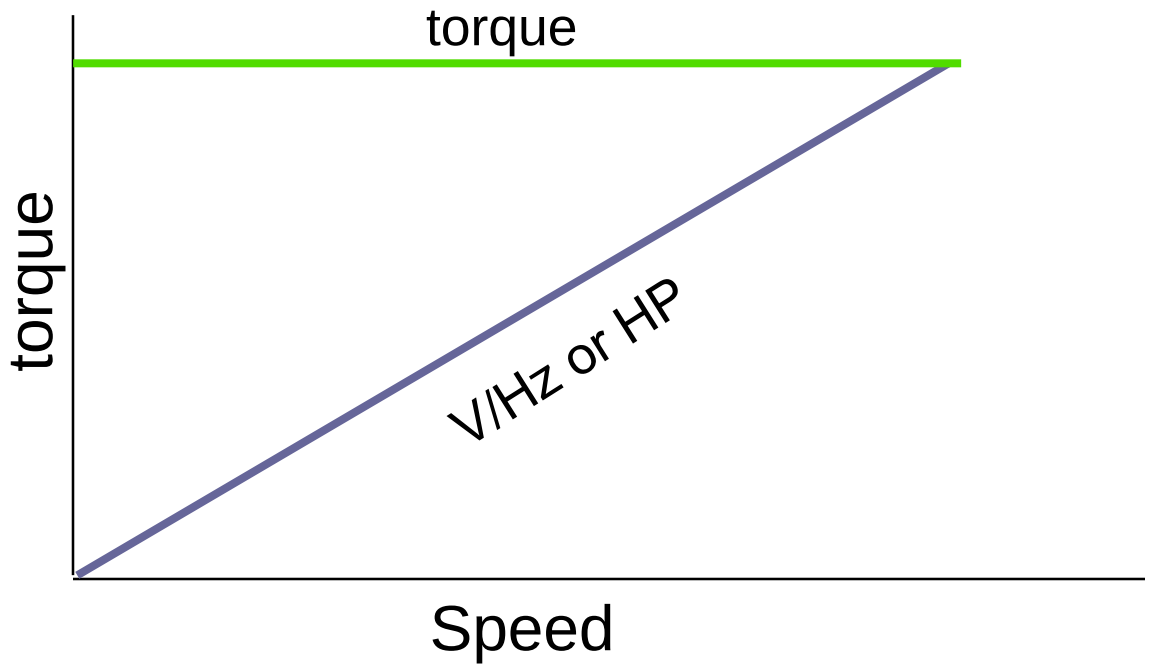
## Tools & Safety Issues

- **Minimum Required Features**
  - UL Listed Device
  - Electrically Isolated Input Channels!
  - 50Mhz Bandwidth or Greater
  - Digital Storage Capability
  - AC to 600v
  - DC to 1000v

  - Optional
    - Built-in Multi-meter
    - Complex Power & Math

# *Constant torque*

The Torque remains constant from a low speed to base speed

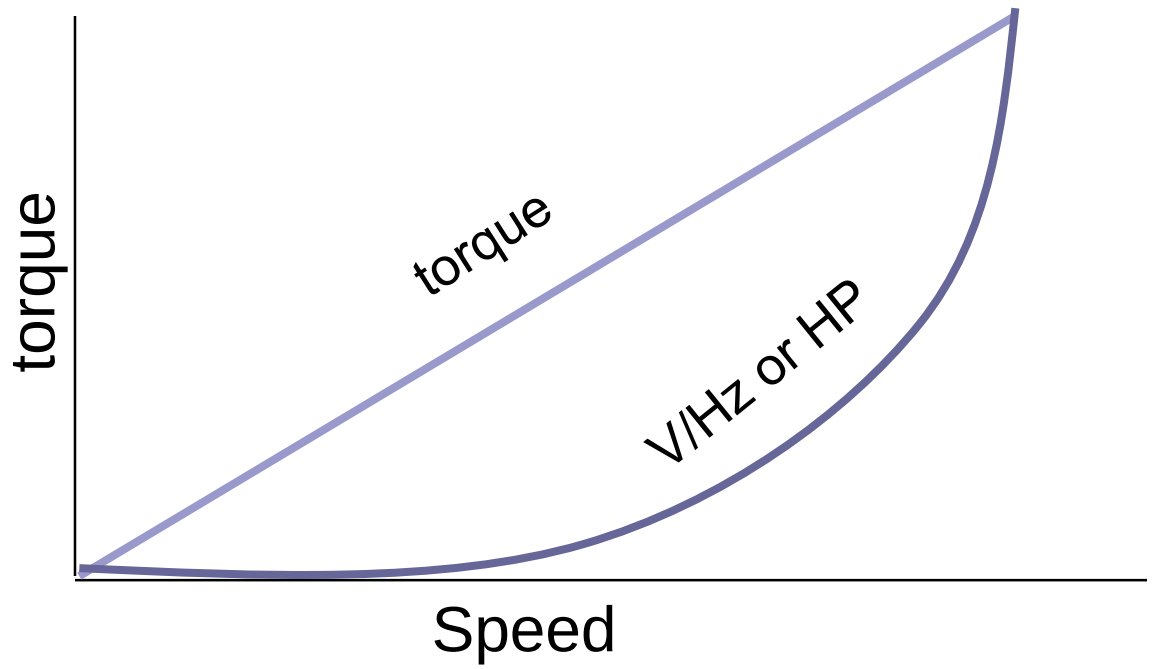


# *Variable torque*

The Load

The Torque Varies by the Square of the speed

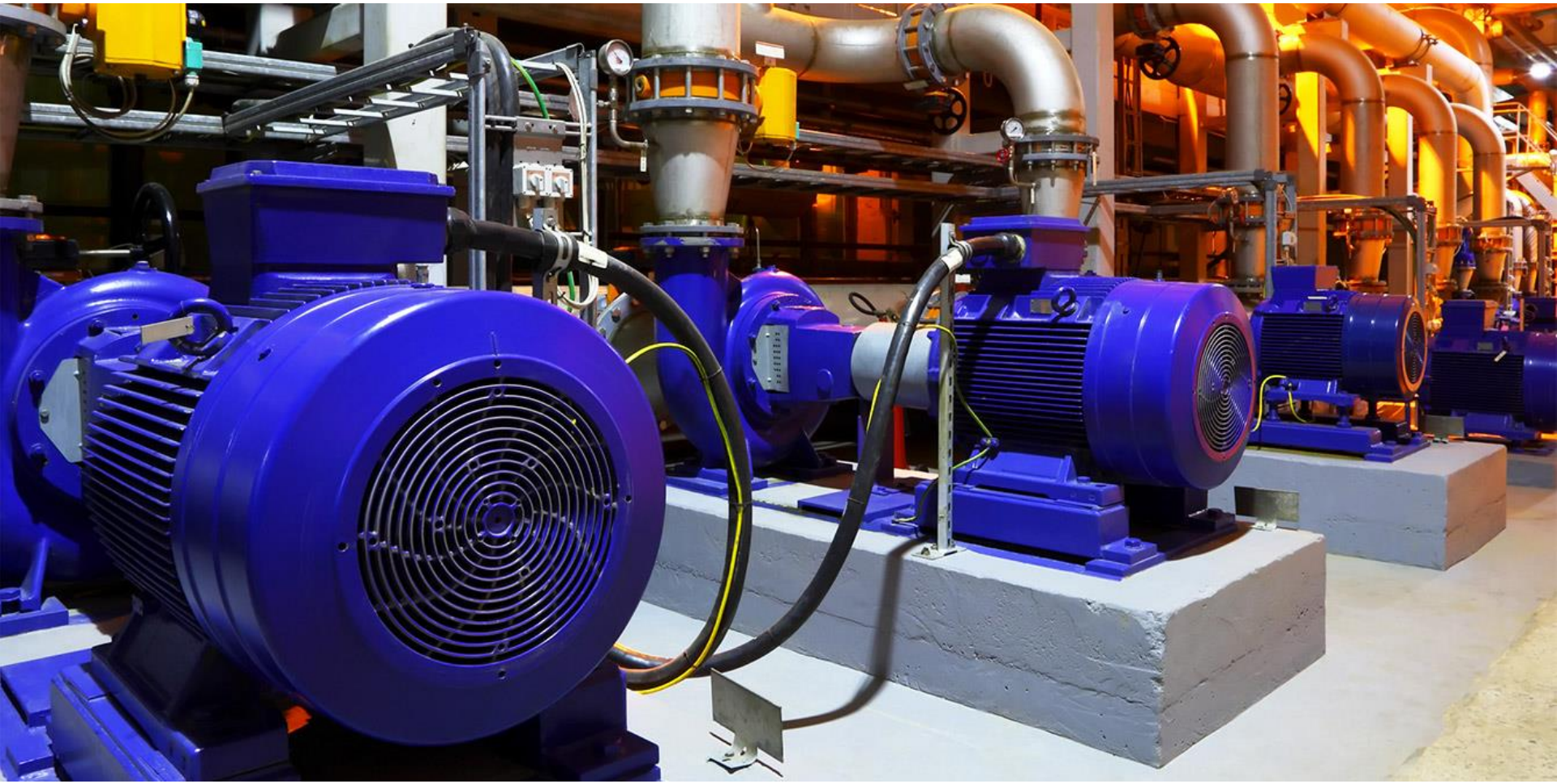
The HP Varies by the Cube of the speed



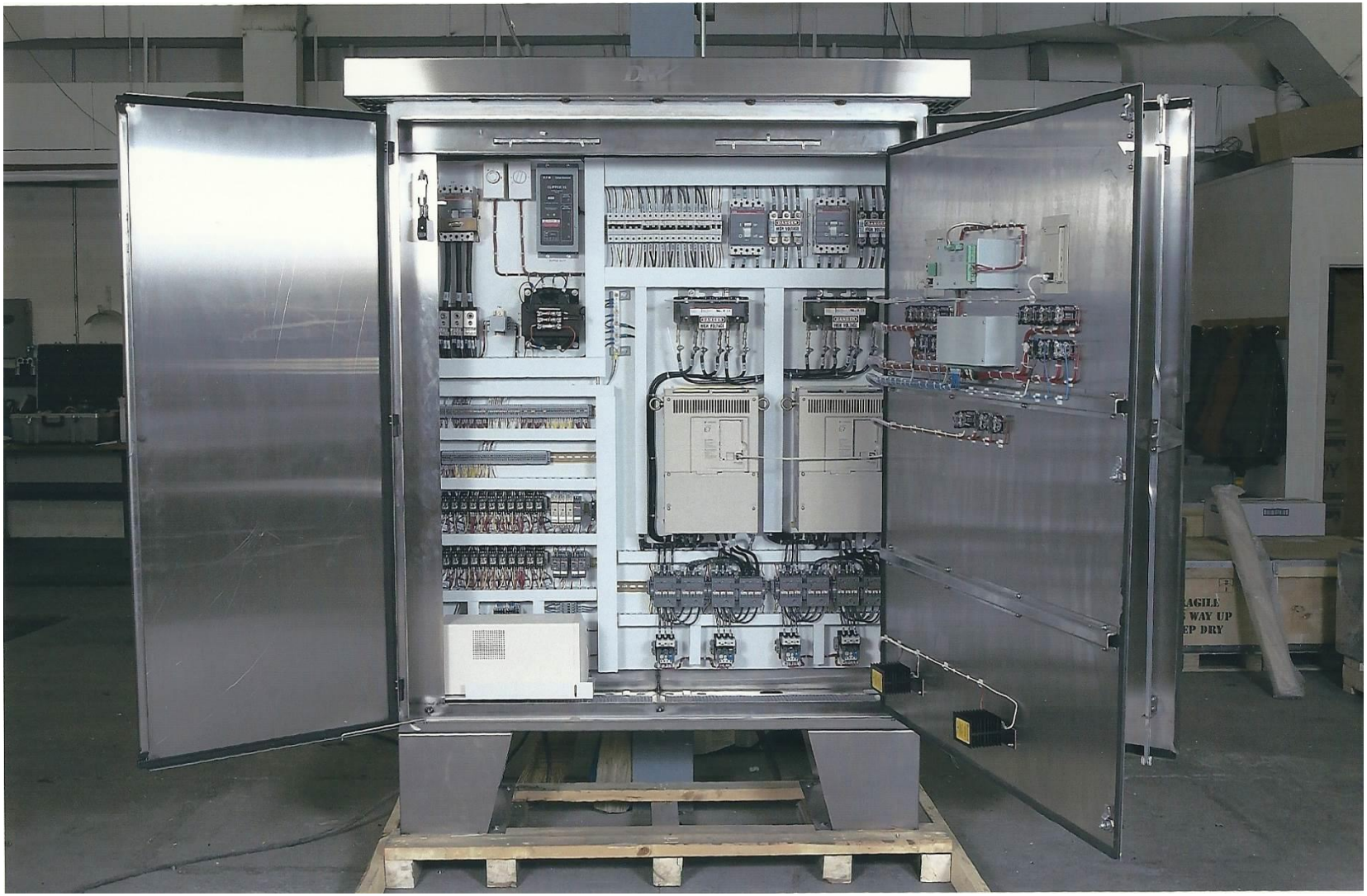
# Other Maintenance Considerations

- What environment is the motor, starters and VFDs in?
  - Moisture
  - Heat
  - Dust and Dirt
  - Vibration
  - Shock
  - Altitude

# Motor and VFD Maintenance



# Control Panel Maintenance



# Outdoor Motor Control Systems

# VFD Packaged Considerations

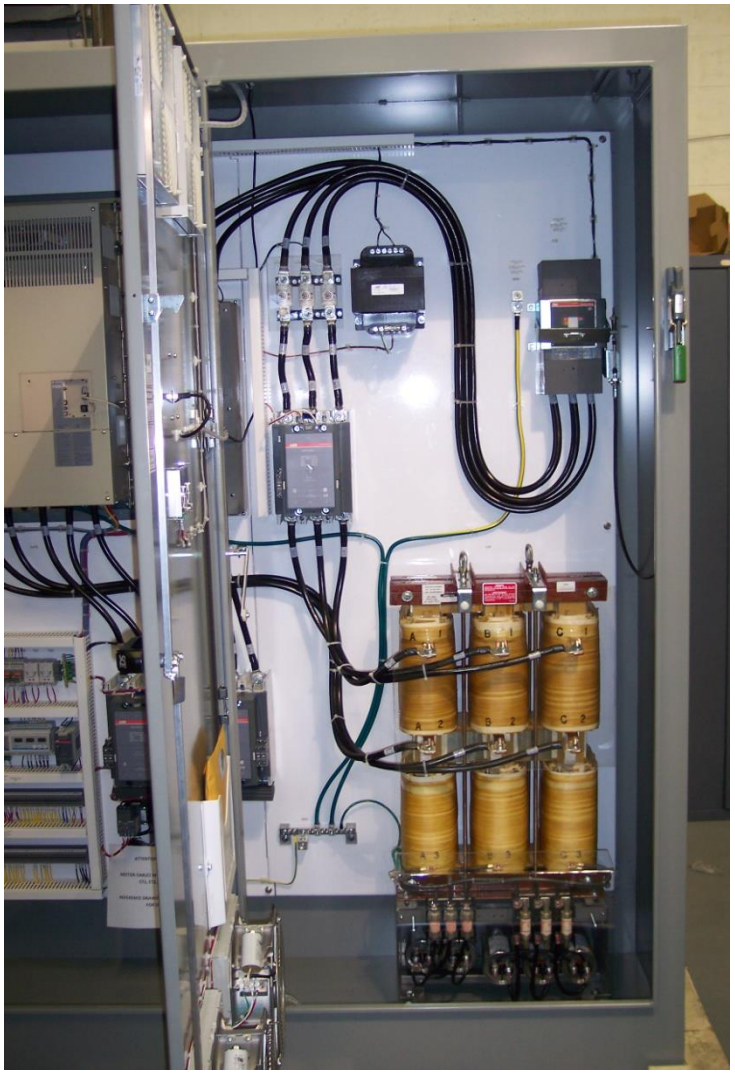
- ENCLOSURE
- COOLING
- POWER DIST.
- DRIVE/STARTER
- CONTROL PWR.
- AUTOMATION
- HARMONICS
- DV/DT
- PROGRAM
- START-UP

# Fan and Filter Maintenance

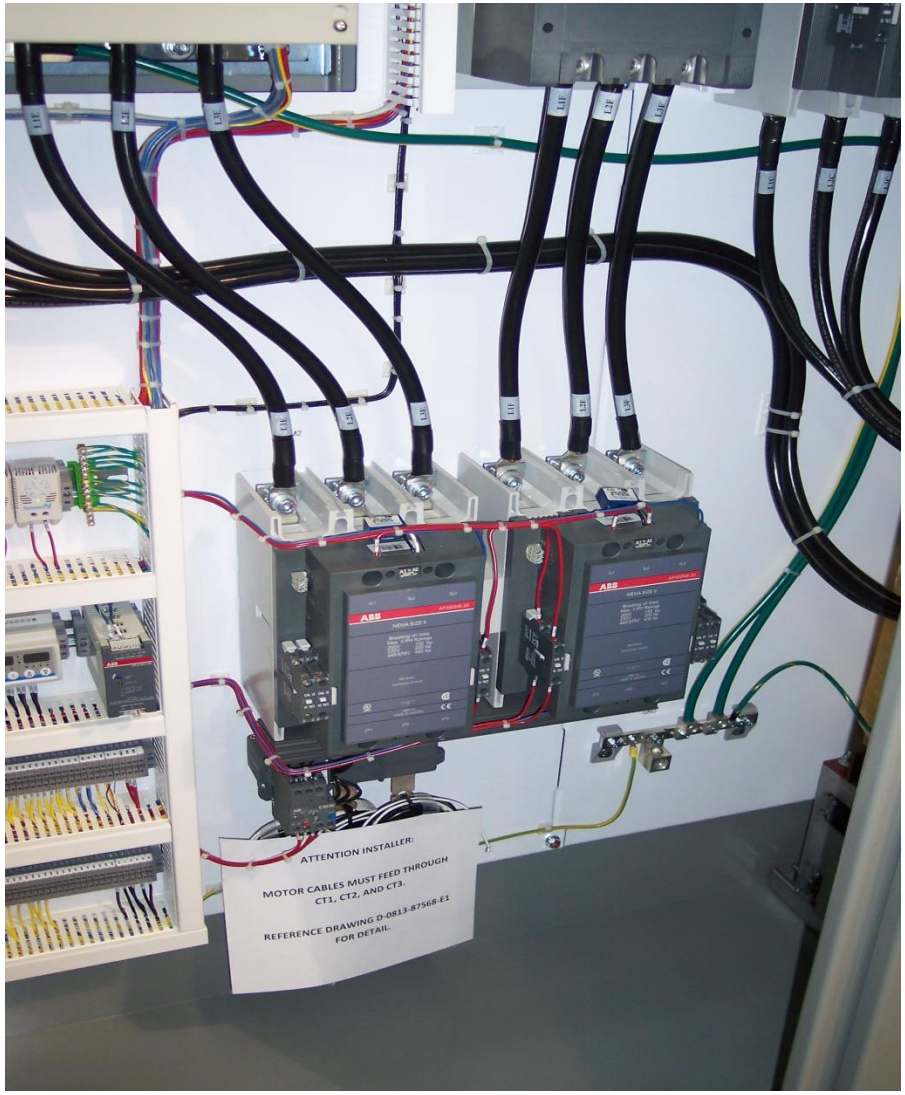
# ENCLOSURE COOLING

- NO COOLING REQUIRED
- FORCED VENTILATED
- FORCED VENTILATED FAN AND FILTER
- FORCE VENTILATED N12 FAN AND FILTER
- HEAT EXCHANGER N12, N4, N4X
- AIR CONDITIONER N4 AND N4X

# POWER DISTRIBUTION



# STARTER SELECTION



# OUTDOOR EQUIPMENT MAINTENANCE

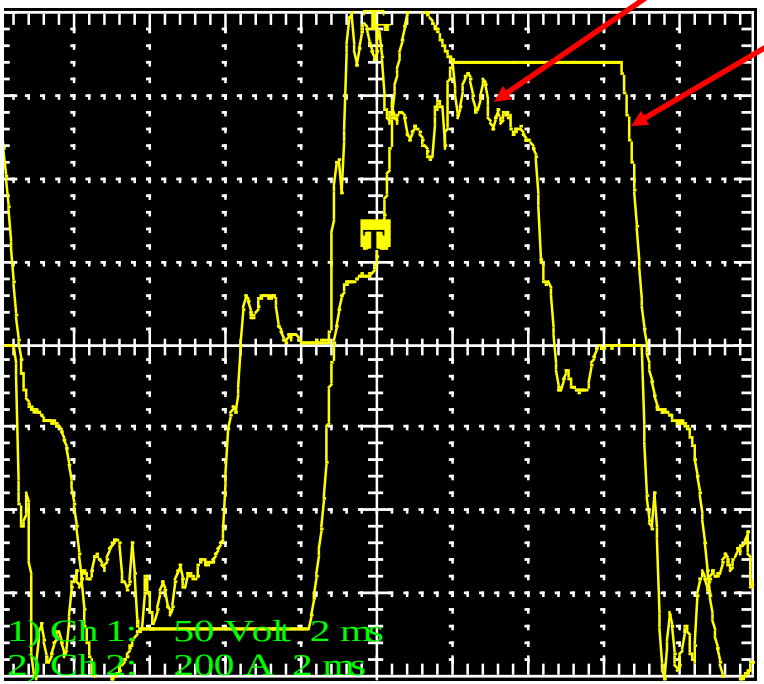
# *Reduce Voltage Distortion caused Current Harmonics*

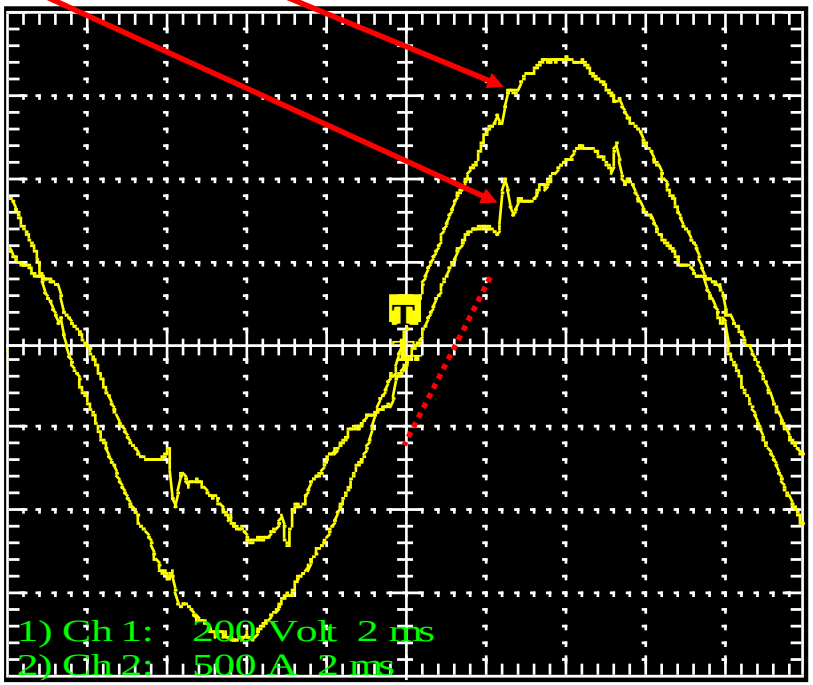
## HARMONIC FILTER Installation

### 150 HP VFD

Current A

Voltage AB



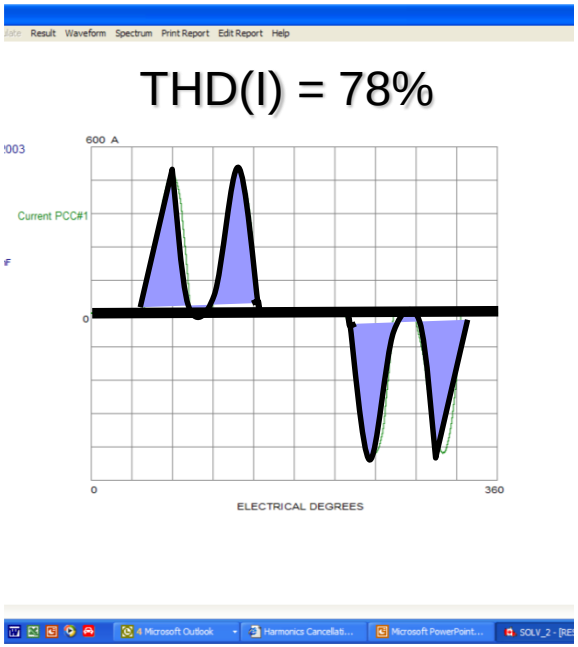



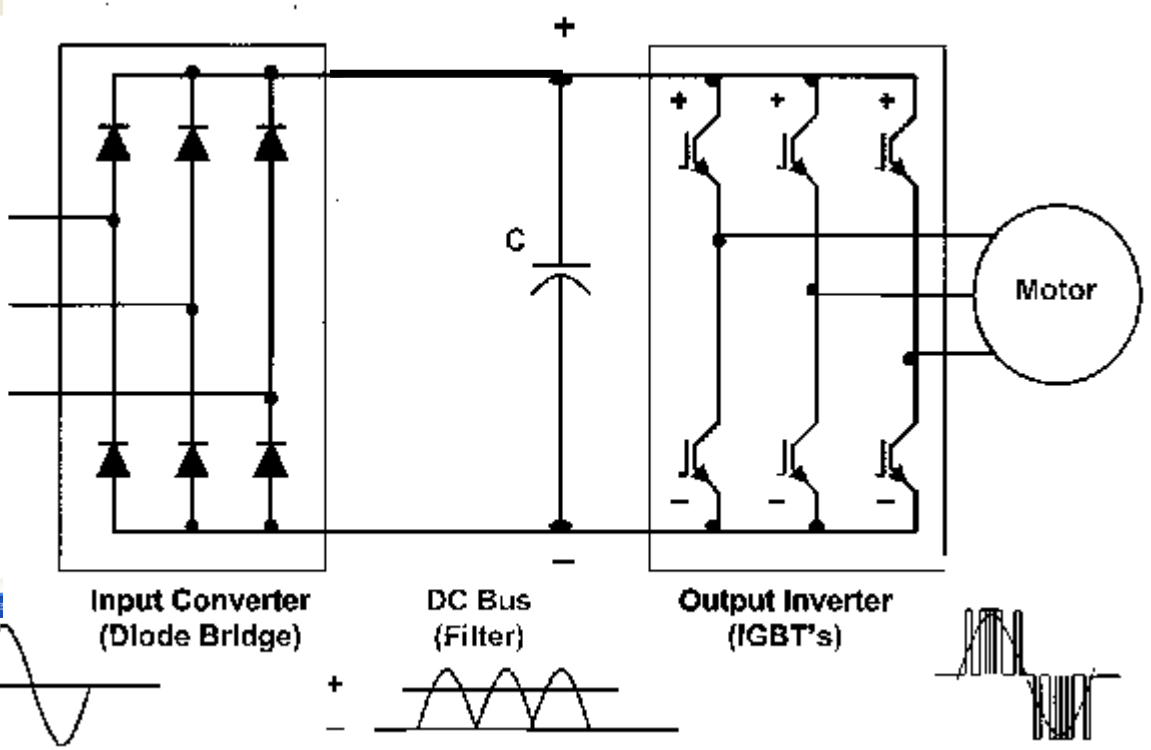

***Input Without Filter Installed***

***Input With Filter Installed***

# Methods Used To Limit Current Harmonics

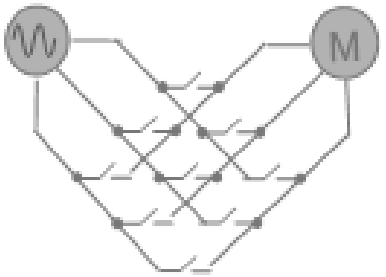
## DO NOTHING



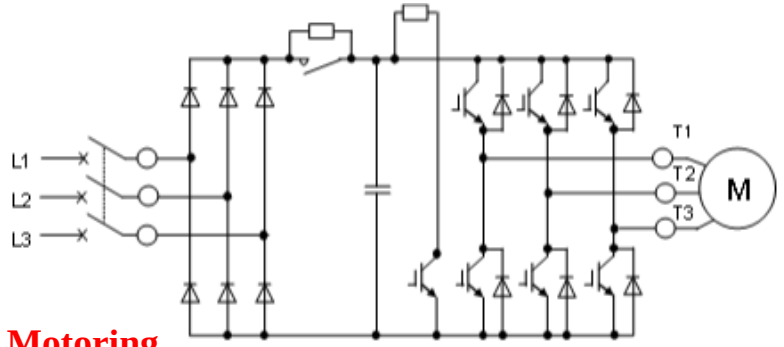
# Matrix Theory

- The Matrix Drive creates precise control of voltage and frequency from 3ph AC power by connecting 9 bi-directional switches like a matrix.
- Differing from conventional drives, the Matrix Drive has no DC link circuit with diode and main capacitor, thus resulting higher efficiency.
- Typical harmonics associated with charging and discharging of DC link capacitors is not present with the Matrix drive.
- The Matrix Drive can return power during regeneration which can be re-used by loads connected to the same power source.




【9 bi-directional switches】

【Circuit configuration - general-purpose drive】

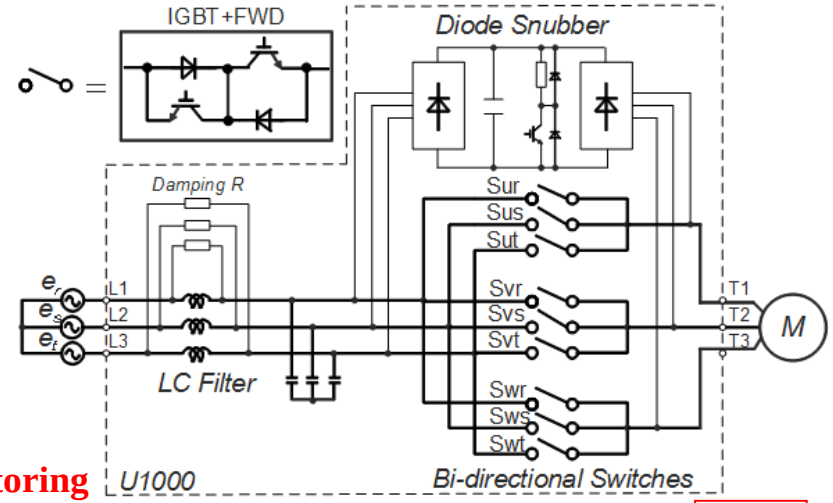



Motoring

AC → DC → AC

Regenerating

【Circuit configuration – U1000 Matrix】




Motoring

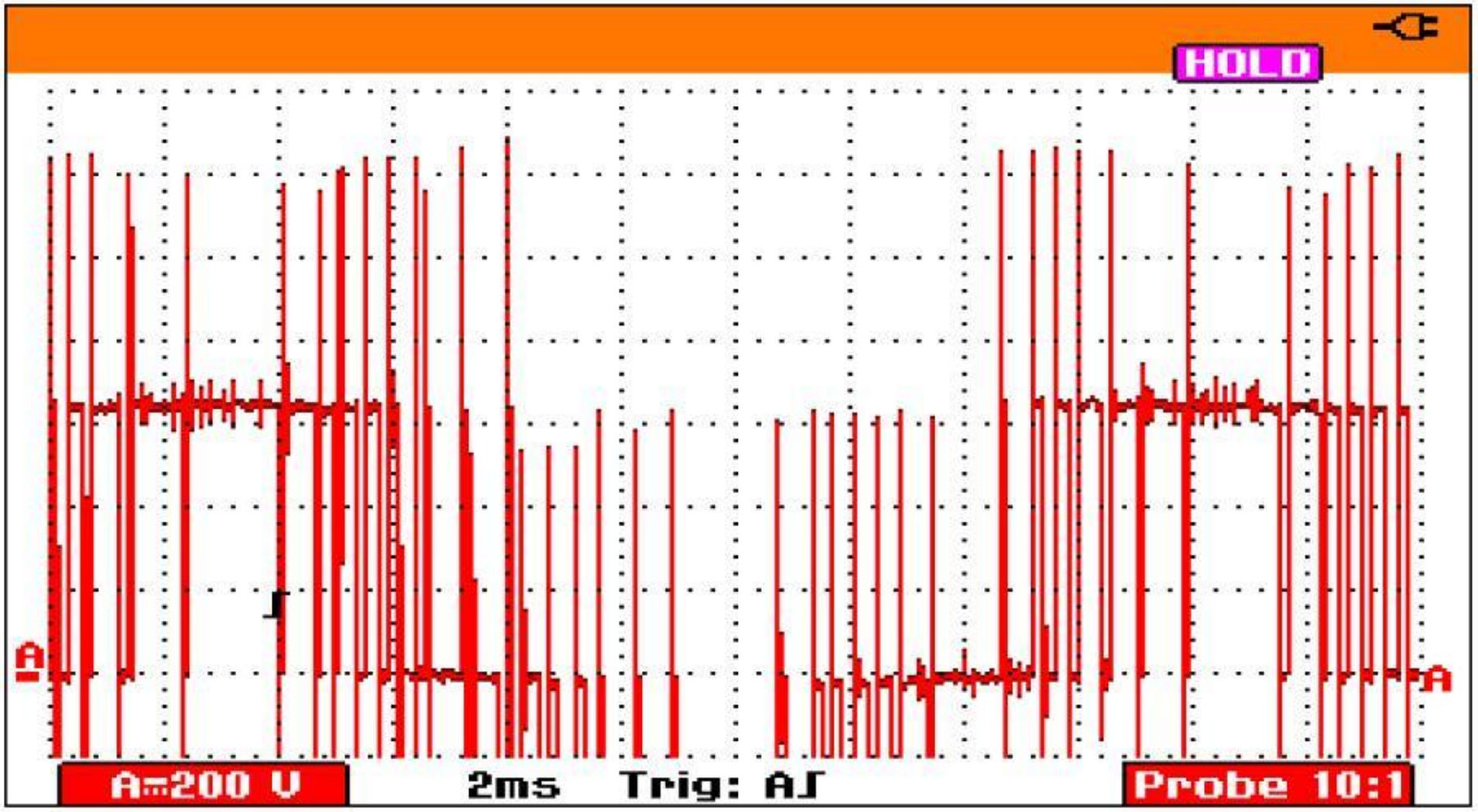
AC → AC

Regenerating

# Output Line Reactors and dV/dT Filters

- Output line reactors use the same principle as input reactors.
- Inductance

# Almost 1400V P-P



# Under 1000V P-P

# Thank you!