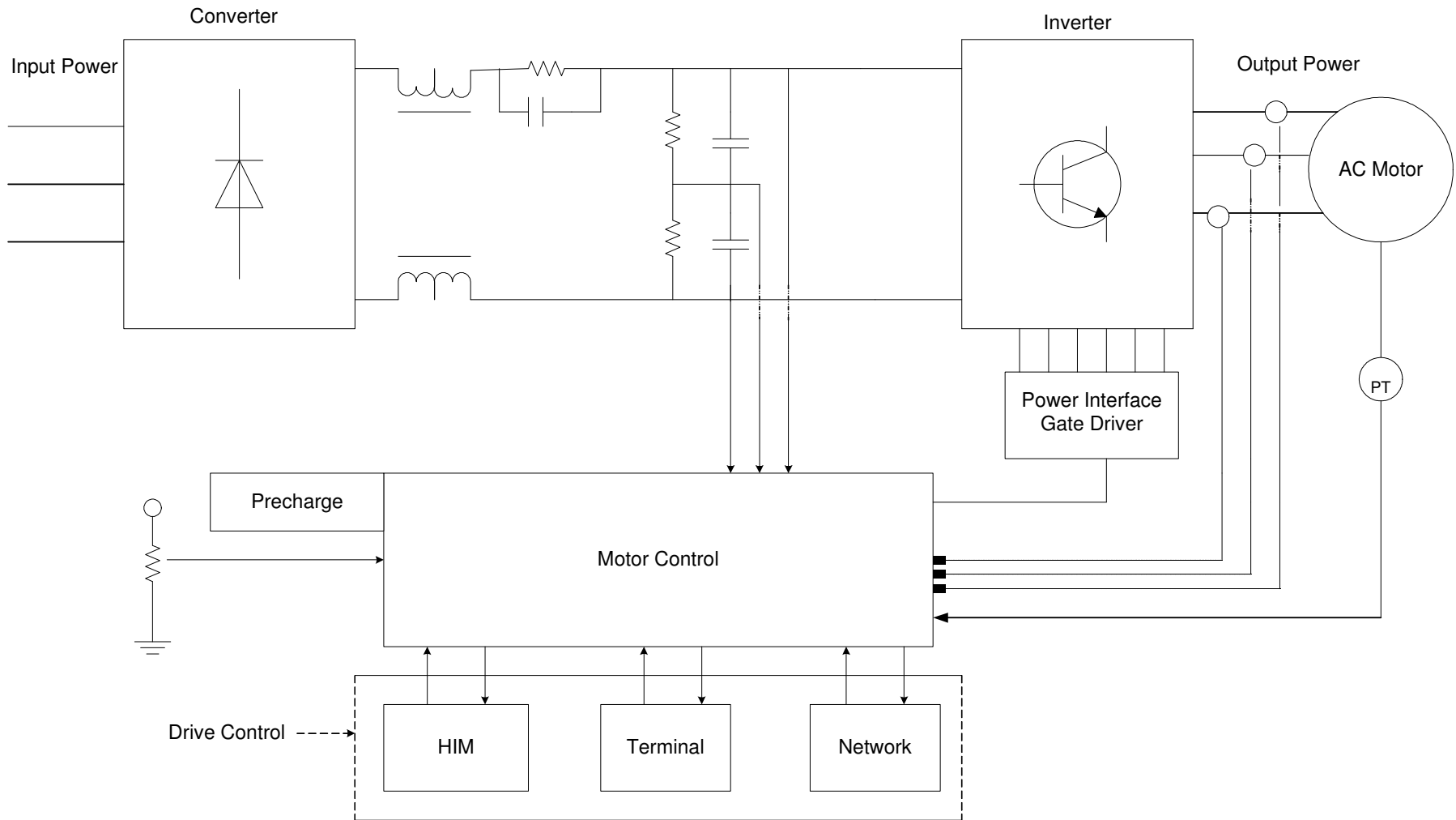# What is a PWM Drive?

A Pulse Width Modulated Drive is used to control a AC motor connected to a load that will produce a product.
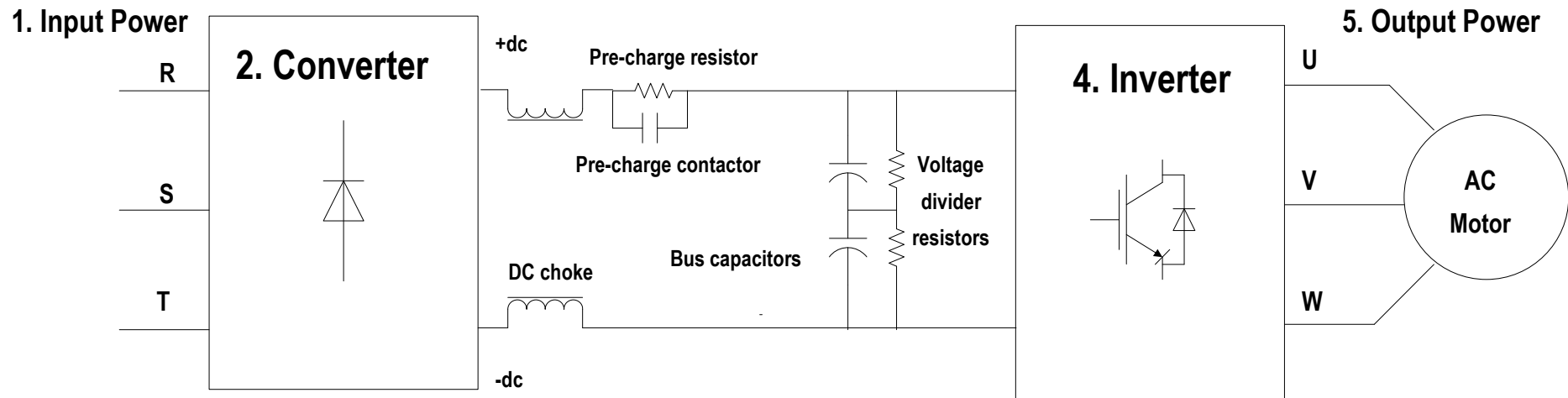
6 Functional Block Diagram Approach

- The basic operation of a Pulse Width Modulated Drive can easily be explained using 6 functional blocks. In this lesson we will discuss the 6 functional blocks and how they work together to control the AC motor.

The 6 Functional Blocks are

1. Input Power
2. Converter
3. Drive Control
4. Inverter
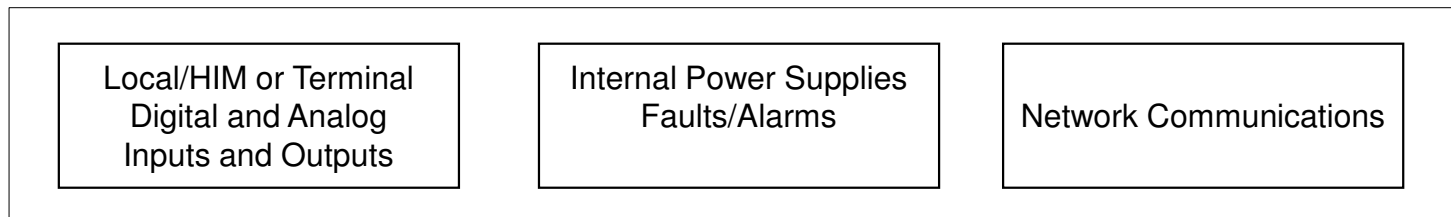5. Output Power
6. Motor Control

Converter

Inverter

Input Power

Output Power

AC Motor

PT

Power Interface
Gate Driver

Precharge

Motor Control

Drive Control

HIM

Terminal

Network

6 Block Diagram

1. Input Power

5. Output Power

R

S

T

2. Converter

+dc

Pre-charge resistor

Pre-charge contactor

DC choke

Bus capacitors

Voltage divider resistors

4. Inverter

U

V

W

AC Motor

-dc

6. Motor Control

Process/Outer Loop Control	Speed/VPL Loop Control	Torque/Current Loop Control

3. Drive Control

Local/HIM or Terminal Digital and Analog Inputs and Outputs	Internal Power Supplies Faults/Alarms	Network Communications

Block 1 - Input Power

1. Input Power

R
——————

S
——————

T
——————

Block 1 - Input Power

- Single phase power can be used on some small horsepower drives

- 3 Phase AC Input voltage, 240, 480 or 575VAC

- Input Fuses – Provide current protection

- Input Transformer - are used in front of drives to provide isolation or they can provide step up or step down of voltages

- Input Reactors - are used to reduce harmonics.

- Grounded and ungrounded systems are used.

- MOVs – Metal Oxide Varistors provide voltage surge protection as well as phase to phase and phase to ground protection.

- Common mode capacitors - Can capture high frequency common mode noise and ground fault currents.
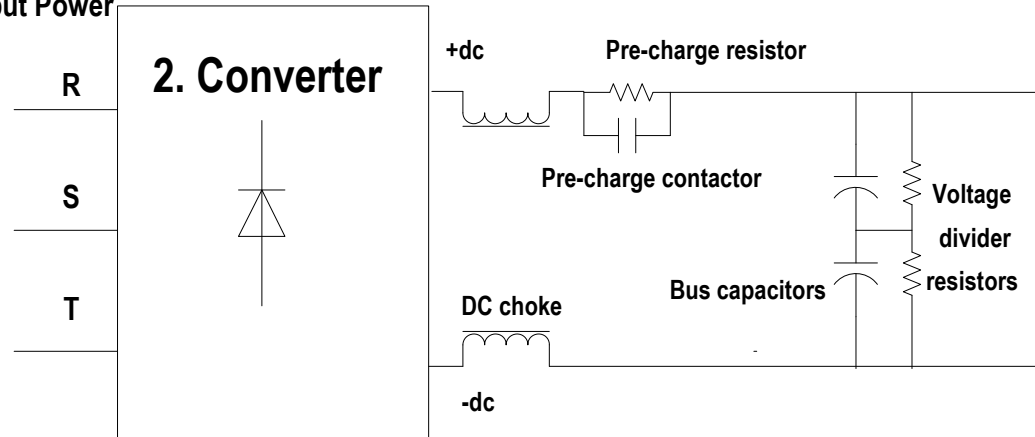
Block 2 - Converter

1. Input Power
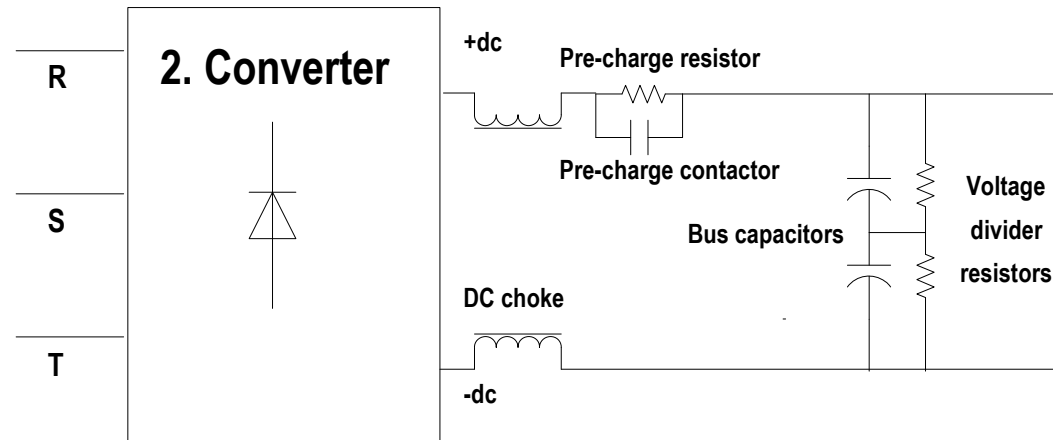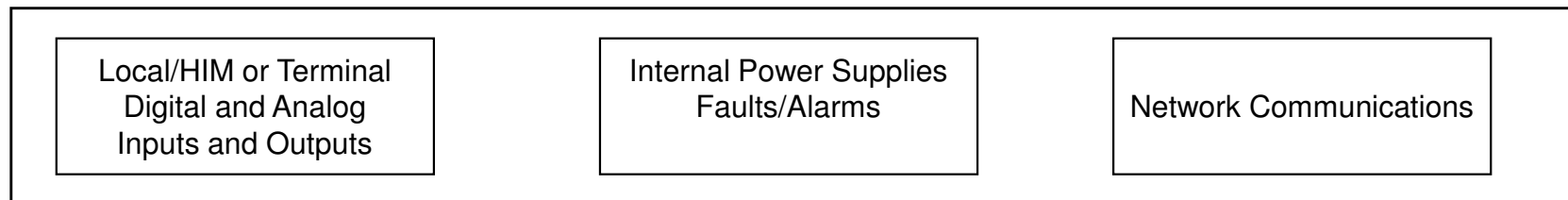
Block 2 - Converter

- Rectifies AC to DC voltage using scr's/diodes
- Pre-charge resistor – Limits in rush current on power up
- The DC Bus supplies voltage for low voltage supplies that will provide isolated low voltage power (+/-15vdc, +5) to the other blocks.
- Pre-charge contactor – will close when the DC bus reaches the correct value as determined by the drive control block..
- Voltage divider resistors – Keeps the voltage equal across the bus capacitors and provides a discharge path on power down.
- DC Bus capacitors store the energy that will be used by the motor
- The DC chokes on the DC Bus help to reduce noise and harmonics that are generated by the drive.
- The DC chokes also help reduce nuisance over voltage faults.
- The bus capacitors will supply the energy for the motor.

Block 3 – Drive Control

1. Input Power

2. Converter

R

S

T

+dc

Pre-charge resistor

Pre-charge contactor

DC choke

-dc

Bus capacitors

Voltage divider resistors

3. Drive Control

| Local/HIM or Terminal Digital and Analog Inputs and Outputs | Internal Power Supplies Faults/Alarms | Network Communications |

Block 3 - Drive Control

- Monitors the DC bus to determine when to close the pre-charge contactor.

- Controls Stop/Start/Jog Direction

- Selects the reference source

- Parameter programming and configuration

- Displays fault/alarm or status information

- Used to clear faults and alarms

- Used to reset drive to default parameters

Drive Control - Digital Inputs and Outputs

- Terminal Inputs
  - Stop/Start/Jog
  - Fwd/Rev motor rotation
  - Reference and reference selection
  - Drive enable (run permissive) coast stop
  - 115vac or 24 volt DC inputs
- Terminal Outputs
  - Indicators for Stop/Start/Faults/Alarms
  - Control output contactors
  - Control output relays

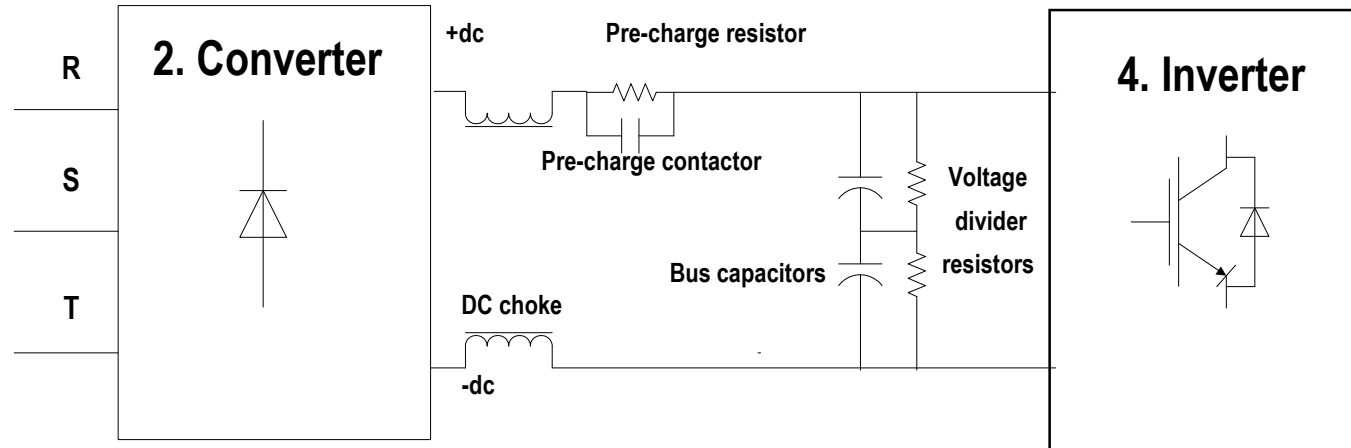# Drive Control - Analog Inputs and Outputs

- Analog Inputs

  – Reference source

  – Trim reference or fine tuning of reference source

  – Current 4 – 20 ma

  – Voltage 0-10 or -10 to + 10 volts

- Analog Outputs

  – Indicators for speed, volts, amps, etc.

  – Indicate a specified condition is met

  – Display output frequency, RPM, current or voltage

  – Display drive parameter information

  – 0-10 volt or -10 to + 10 volts

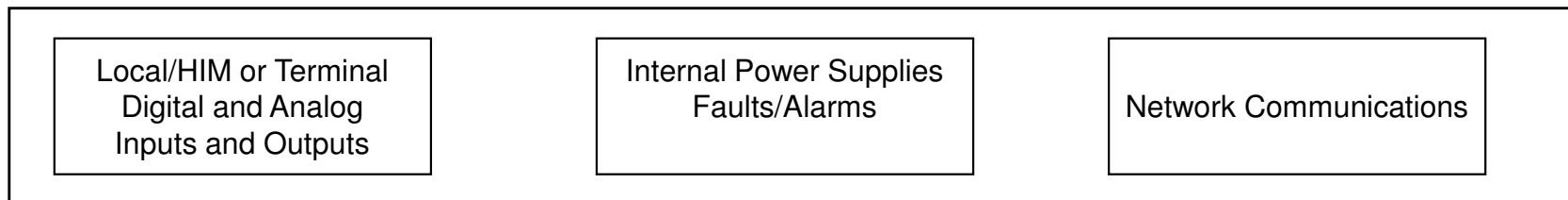 – 4 – 20 ma

Drive Control - Network Communications

- Allows a drive to be controlled and monitored by a processor on a communication network.

- A processor can read and write drive information
  - Command and Status words
  - References
  - Feedbacks
  - Faults and Alarms
  - Datalinks – can be used to transmit and receive scheduled data between the drive and the processor.
  - Messaging can be used to send and receive additional data.
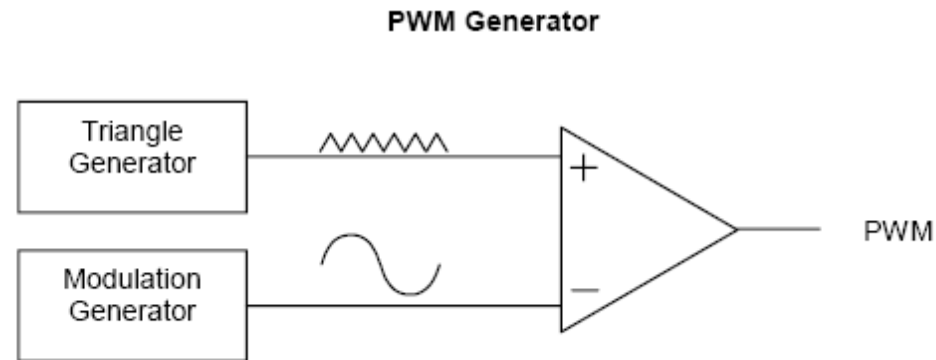
Block 4 - Inverter

1. Input Power

2. Converter

R

S

T

+dc

Pre-charge resistor

Pre-charge contactor

DC choke

-dc

Bus capacitors

Voltage divider resistors

4. Inverter

3. Drive Control

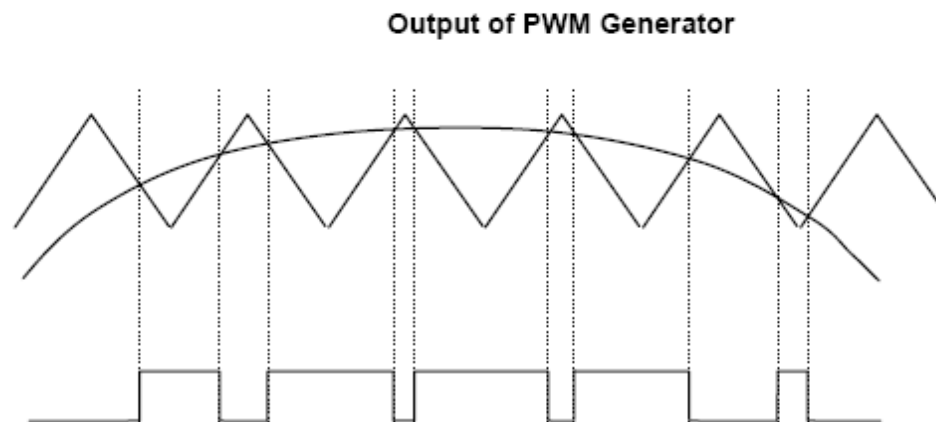| Local/HIM or Terminal Digital and Analog Inputs and Outputs	Internal Power Supplies Faults/Alarms	Network Communications

Block 4 - Inverter

- Converts DC to AC PWM – Pulse Width Modulation

- Outputs voltage and frequency to the connected motor.

- IGBT's – Insulated Gate Bipolar Transistors (switches) are turned off and on at different times to control the output voltage and frequency.

- Monitors motor voltage, frequency and current feedback from the motor.
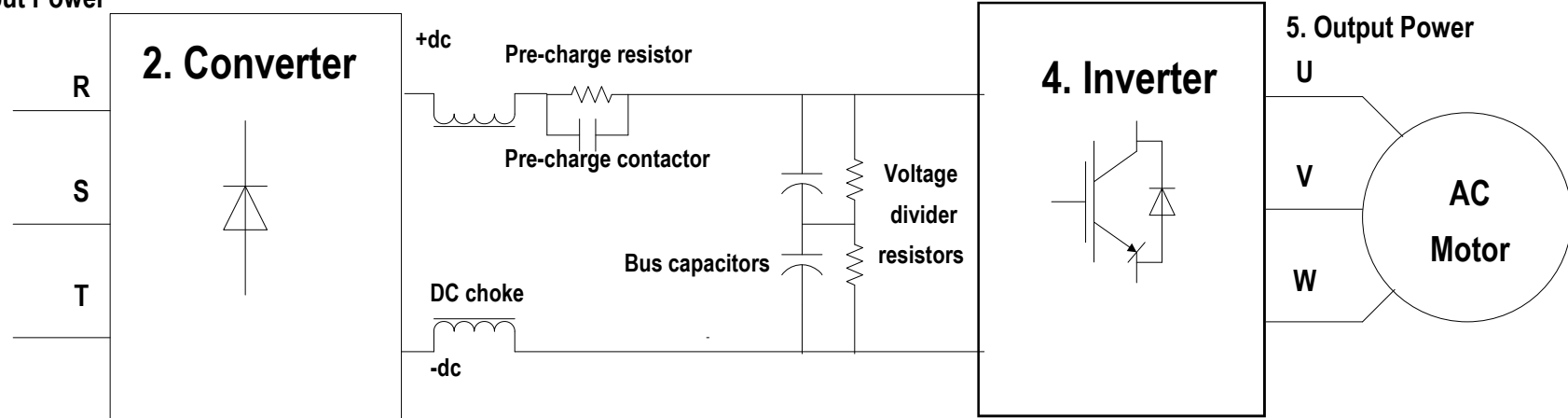
Inverter - PWM

PWM Generator

The triangular signal is the carrier or switching frequency of the inverter. The modulation generator produces a sinewave signal that determines the width of the pulses, and therefore the RMS voltage output of the inverter.
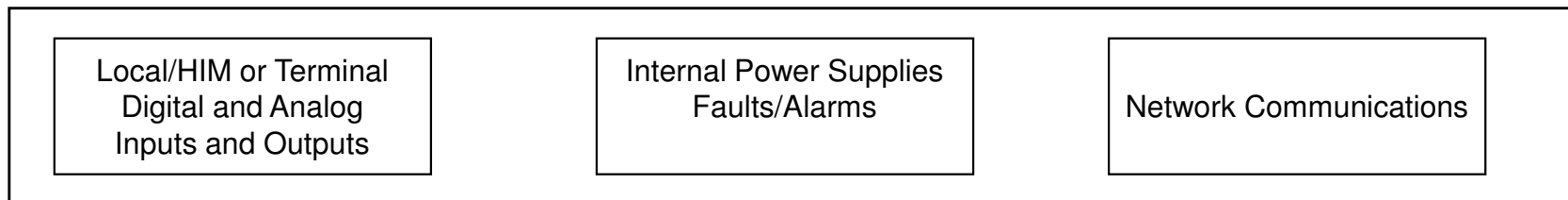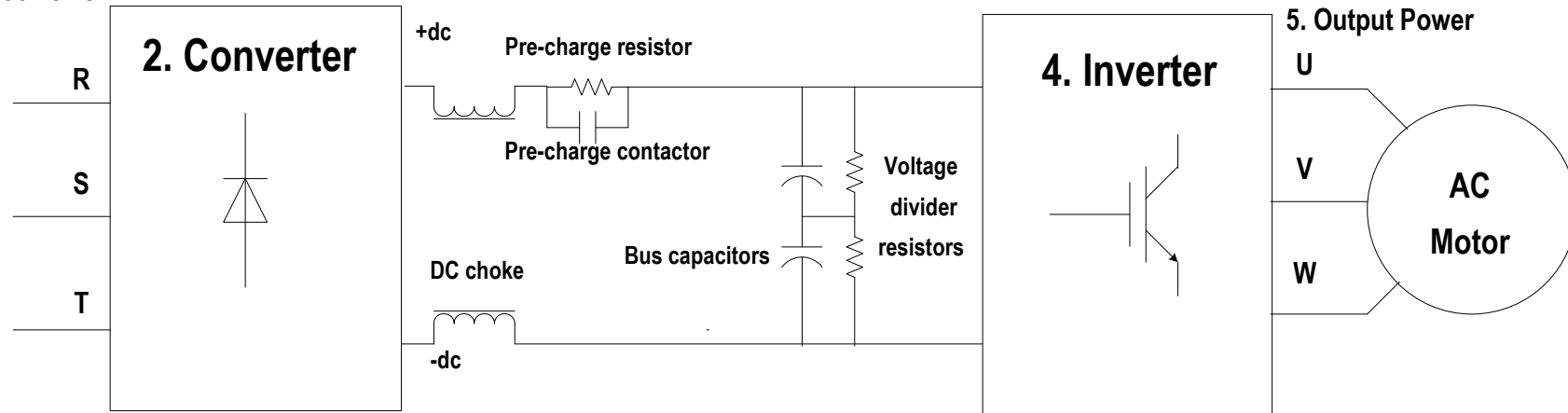
Output of PWM Generator

Block 5 - Output Power

1. Input Power

2. Converter

R

S

T

+dc

Pre-charge resistor

Pre-charge contactor

DC choke

-dc

Bus capacitors

Voltage divider resistors

4. Inverter

5. Output Power

U

V

W

AC Motor

3. Drive Control

Local/HIM or Terminal Digital and Analog Inputs and Outputs	Internal Power Supplies Faults/Alarms	Network Communications

Block 6 – Motor Control

1. Input Power

2. Converter

+dc

Pre-charge resistor

Pre-charge contactor

R

S

T

DC choke

-dc

Bus capacitors

Voltage divider resistors

4. Inverter

5. Output Power

U

V

W

AC Motor

6. Motor Control

Process/Outer Loop Control	Speed/VPL Loop Control	Torque/Current Loop Control

3. Drive Control

Local/HIM or Terminal Digital and Analog Inputs and Outputs	Internal Power Supplies Faults/Alarms	Network Communications
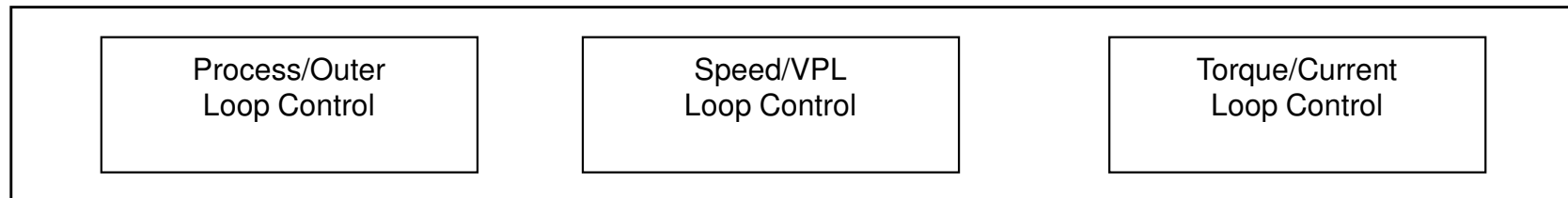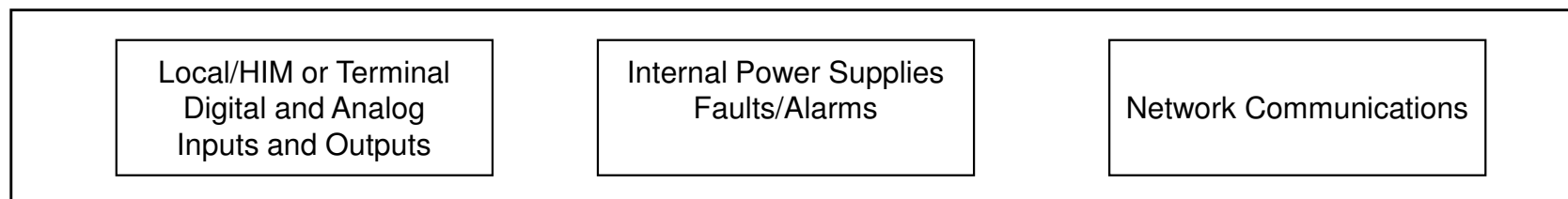
Motor Control

- How well we can regulate the motor is also a function of how the regulator is configured.

- Open Loop Control – no speed or position feedback device

- Closed Loop Control – Requires speed or position feedback

Block 6 - Motor Control

- How well the drive will control the performance of the motor is determined by motor control block. There are 4 motor control types.

- 1. Volts/Hertz control is a basic control method providing a variable frequency drive for applications like fan and pump

- 2. Sensorless Vector control provides better speed regulation and the ability to produce a high starting torque.

- 3. Flux Vector control provides more precise speed and torque control with dynamic response

- 4. Field Oriented Control drives provide the best speed and torque regulation available for AC motors.

Motor Control - Velocity or Speed Control

- VPL – Velocity processor loop or speed loop.

- Closed loop speed regulation is used to control the speed of the of the motor.

- The commanded speed will be maintained even if the load changes

- Closed loop regulation requires reference and feedback

- The speed of the motor is monitored with a speed feedback device. (encoder, resolver, etc).

Motor Control - Motor or Torque Loop Control

- The torque loop is used to regulate the current, (torque) the drive outputs to the motor.

- A torque regulator will maintain or regulate the amount of torque to the motor even if the speed changes.

- Torque reference and current feedback are required for closed loop operation.

- Can limit the amount of positive and negative current or torque the drive will output under normal conditions.

- Torque is proportional to load in most cases

- The motor demands the torque based on load

Motor Control - Process or Outer Control Loop

- An additional trim reference can be used to fine tune the drives position, speed or torque loops.

- The user can monitor the process adjust the motors performance as needed.

Closed Loop Control
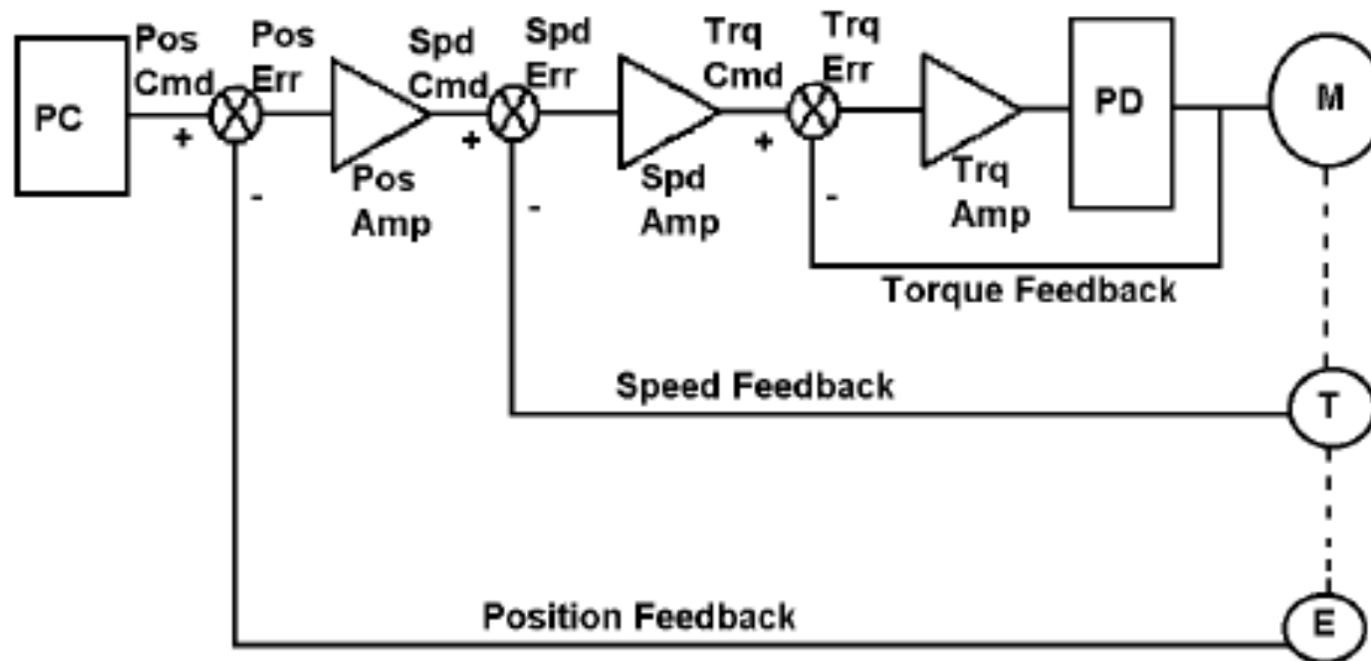
Drive sequence of events

- 1. Apply AC power
- 2. The DC bus will begin to charge up through the precharge resistor.
- 3. The DC bus creates power for the control boards.
- 4. The processors monitor the faults, alarms and bus voltages.
- 5. The pre-charge contactor will close when DC Bus reaches correct value.
- 6. Drive should be in a ready to run condition
- 7. Press start and the inverter will able to produce voltage and frequency at the motor output terminals.
- 8. If a reference is present the motor will rotate.
- 9. The amount of frequency and voltage to the motor will depend on the motor control mode and determine the motor speed.