**Rectifier**
A device or circuit that converts *alternating current* to *direct current*.

![Rectifier Diagram]

**Reduced-Voltage Controller**
A type of *motor starter* that applies less than the full-line *voltage* to a three-phase induction motor while it is starting. A variety of types of reduced-voltage controllers exist including *solid-state* starters.

![Reduced-Voltage Controller Diagram]

**Resistance**
A property of a material or circuit to oppose *current* flow. Resistance is symbolized by “R” and is measured in *ohms*.

**Resistance Temperature Detector (RTD)**
A device used to sense temperature that varies in *resistance* as temperature changes.

**Resistor**
A device manufactured to have a specific amount of *resistance*.

![Resistor Formula]

**Resolver**
An angular position sensing device that utilizes a rotating transformer with two secondary windings arranged at right angles to each other to provide angular position information. The amplitude of the wave induced into each stator winding depends on the angular position of the rotor winding. Since the amplitude variations available at the stator windings are 90° apart, one is called a sine signal and the other is called a cosine signal.

![Resolver Diagram]
**Root-mean-square or RMS Value**

The *effective value* of a *current* or *voltage*. Root-mean-square is descriptive of the mathematical process used to calculate the effective value of a periodic current or voltage.

**Rotor**

The rotating elements of the magnetic circuit of a rotating machine such as a *motor*.

![Rotor Image]

**Safety Switch**

A switch mounted in an *enclosure*. Fusible enclosed switches include provisions for *fuses* in the enclosure.

![Safety Switch Image]

**Secondary Unit Substation**

A coordinated design consisting of one or more *transformers* mechanically and electrically linked to *switchgear* or *switchboard* assemblies with an outgoing *voltage* rated below 1000 *volts*.

![Secondary Unit Substation Image]

**Selective Coordination**

Applying *circuit breakers* in a manner that will minimize the extent of an outage in the event of a fault. Circuit breakers are typically installed in a branching arrangement. In the event of a fault, the breaker electrically closest to the fault should trip first. This can be accomplished by properly sizing and adjusting all breakers.

![Selective Coordination Diagram]
Selector Switch
A control device with two or more positions used to manually open and close contacts.

Semiconductor
A special type of material with more resistance than a conductor, but less than that of an insulator. Semiconductors can be manufactured to produce devices such as diodes, transistors, thyristors, etc.

Sensing Switch
A device, often called a sensor, used to provide information on the presence or absence of an object. Examples include a limit switch, photoelectric sensor, inductive proximity sensor, capacitive proximity sensor, and ultrasonic proximity sensor.

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limit Switch</td>
<td>• High Current Capability</td>
<td>• Requires Physical Contact with Target</td>
<td>• Interlocking</td>
</tr>
<tr>
<td></td>
<td>• Low Cost</td>
<td>• Very Slow Response</td>
<td>• Basic End-of-Travel Sensing</td>
</tr>
<tr>
<td></td>
<td>• Familiar “Low-Tech” Sensing</td>
<td>• Contact Bounce</td>
<td></td>
</tr>
<tr>
<td>Photoelectric</td>
<td>• Senses all kinds of Materials</td>
<td>• Less Subject to Contamination</td>
<td>• Packaging</td>
</tr>
<tr>
<td></td>
<td>• Long Life</td>
<td>• Sensing Range Affected by Color and Reflectivity</td>
<td>• Material Handling</td>
</tr>
<tr>
<td></td>
<td>• Largest Sensing Range</td>
<td>• of Target</td>
<td>• Parts Detection</td>
</tr>
<tr>
<td></td>
<td>• Very Fast Response Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inductive</td>
<td>• Resistant to Harsh Environments</td>
<td>• Distance Limitations</td>
<td>• Industrial and Machines</td>
</tr>
<tr>
<td></td>
<td>• Very Predictable</td>
<td></td>
<td>• Machine Tool</td>
</tr>
<tr>
<td></td>
<td>• Long Life</td>
<td></td>
<td>• Senses Metal-Only Targets</td>
</tr>
<tr>
<td></td>
<td>• Easy to Install</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacitive</td>
<td>• Detects Through Some Containers</td>
<td>• Very Sensitive to Extreme Environmental Changes</td>
<td>• Level Sensing</td>
</tr>
<tr>
<td></td>
<td>• Can Detect Non-Metallic Targets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultrasonic</td>
<td>• Senses All Materials</td>
<td>• Resolution</td>
<td>• Anti-Collision</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Repeatability</td>
<td>• Doors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Sensitive to Temperature Changes</td>
<td>• Web Brake</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Level Control</td>
</tr>
</tbody>
</table>

Serial Communication
Intelligent devices, such as computers, communicate with each other by sending bits of data in a series of binary signals to each other. RS-232 and RS-485 are specifications commonly used in serial communication.
**Service Entrance**

The place where *power* is brought into a building. Also used to describe equipment at the service entrance.

![Service Entrance Diagram](image)

**Service Factor**

A numerical value that is multiplied by a motor’s rated *horsepower* to determine the maximum horsepower at which the motor should be operated.

**Service Head**

A device used to connect *busway* at the *service entrance*.

![Service Head Diagram](image)

**Service Section**

The *switchboard* section connected to incoming *power*.

**Servo Drive**

Usually refers to an electronic device used to control the speed and *torque* of a *servo motor* as part of a closed-loop positioning control system.

![Servo Drive Diagram](image)
Servo Motor

A motor designed with the dynamic response required for closed-loop positioning applications.

Set Point

The value used by a control circuit as desired value of a process variable.

Short Circuit

A normally unintended low resistance path for current.

Shunt Trip

A device used to remotely trip a circuit breaker.

Single Quadrant Operation

Describes the operation of a variable speed drive that can provide torque to drive the motor, but cannot provide braking torque.

Slip

In a three-phase induction motor, slip is the difference between the synchronous speed and the rotor speed and is often expressed as a percentage.

\[ \% \text{ Slip} = \frac{N_s - N_r}{N_s} \times 100 \]

Solid-State

Used to describe equipment that contains semiconductor devices in an electronic circuit.
**Speed-Torque Curve**

A graphical representation of the **torque** provided by a motor over a range of speeds.

![Graph of Speed-Torque Curve](image)

**Splice Plates, Splice Bars**

Plates used to join the horizontal **bus bars** of adjoining **switchboard** or **motor control center** sections.

![Diagram of Splice Plates and Bars](image)

**Starter Ratings**

**Motor Starters** are rated according to size and type of load. **NEMA** and **IEC** rate **motor starters** differently. **IEC**-rated devices are rated according to maximum operational **current**. **NEMA** specifies sizes from size 00 to size 9.

<table>
<thead>
<tr>
<th>Size of Controller</th>
<th>Horsepower at 460V/60 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
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<tr>
<td>5</td>
<td>200</td>
</tr>
<tr>
<td>6</td>
<td>400</td>
</tr>
<tr>
<td>7</td>
<td>600</td>
</tr>
<tr>
<td>8</td>
<td>900</td>
</tr>
<tr>
<td>9</td>
<td>1600</td>
</tr>
</tbody>
</table>
**Stator**
The stationary elements of the magnetic circuit of a rotating machine such as a motor.

**Step-down Transformer**
A transformer with more turns of wire in its primary coil than in its secondary coil. The step-down transformer is used to step down the primary voltage to a lower secondary voltage.

**Step-up Transformer**
A transformer with fewer turns of wire in its primary coil than in its secondary coil. The step-up transformer is used to step up the primary voltage to a higher secondary voltage.

**Surge**
A transient increase in current and voltage.

**Surge Protection**
Used to describe equipment designed to prevent or limit damage resulting from a surge, provided that the surge does not exceed the capabilities of the protection devices.
**Switchboard**
A large panel or assembly of panels containing switches, **overcurrent** protective devices, buses, and associated instruments.

**Switchgear**
A coordinated design consisting of switching and interrupting devices and associated equipment such as control and protective devices and metering.

**Synchronous Speed**
The speed of the rotating magnetic field in a three-phase motor. Synchronous speed is determined by the line **frequency** and the number of motor poles.

\[
N_s = \frac{120f}{P} \text{ Frequency No. of Poles Synchronous Speed}
\]

**Tachometer**
A device used to provide a **feedback** signal representative of the speed of a rotating machine. Some tachometers are **analog** devices. Others provide a **digital** signal.
**Thermal-Magnetic**

Used to describe a device that uses both heat and magnetism as part of its operating principles. For example, a thermal-magnetic *circuit breaker* can be tripped either by heat or magnetic force resulting from excessive *current*.

![Thermal-Magnetic Circuit Breaker Diagram](image)

**Thermistor**

A device used to sense temperature that varies in *resistance* as temperature changes.

**Thermocouple**

A device composed of two types of metal that produces a small *voltage* representative of the temperature at some point in a process.

**Thyristor**

A family of multi-layer *semiconductor* devices that includes silicon controlled rectifiers (SCR), triacs, and gate turnoff (GTO) thyristors. Thyristors are often used in *rectifier* or *power* switching circuits.